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MULTIDECISION-2: A MULTICRITERIA DECISION SUPPORT SYSTEM

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Abstract: The paper presents a multicriteria decision support system, called MultiDecision-2, which consists of two independent parts - MKA-2 subsystem and MKO-2 subsystem. MultiDecision-2 software system supports the decision makers (DMs) in the solving process of different problems of multicriteria analysis and linear (continues and integer) problems of multicriteria optimization. The two subsystems MKA-2 and MKO-2 of of MultiDecision-2 are briefly described in the paper in the terms of the class of the problems being solved, the system structure, the operation with the interface modules for input data entry and the information about DM's local preferences, as well as the operation with the interface modules for visualization of the current and final solutions.

Keywords: multicriteria decision support systems, multicriteria analysis, multicriteria optimization.

ACM Classification Keywords: H.4.2 Information Systems Applications: Types of Systems: Decision Support.

Introduction

The Multicriteria Decision Support System *MultiDecision-2* system is a successor of system *MultiDecision-1* (Vassilev et al. (2005a)) and the system *MultiDecision-2.1* (Vassilev et al. (2005b)) and it is designed to support DMs in solving different multicriteria analysis and multicriteria optimization problems. The multicriteria analysis problems can be divided into three types: problems of multicriteria choice, problems of multicriteria ranking and problems of multicriteria sorting Many real life problems in management practice may be formulated as problems of choice, ranking and sorting of resources, strategies, projects, offers, policies, credits, products, innovations, designs, costs, profits, portfolios, etc. The multicriteria optimization problems are only problems of multicriteria choice. Many real life problems in planning, control and industrial production may be formulated as problems of multicriteria choice or linear (continues or integer problems) of multicriteria optimization.

In multicriteria analysis and multicriteria optimization problems several criteria are simultaneously optimized in the feasible set of alternatives. In the general case there does not exist one alternative, which optimizes all the criteria. There is a set of alternatives however, characterized by the following: each improvement in the value of one criterion leads to deterioration in the value of at least one other criterion. This set of alternatives is called a set of the non-dominating or Pareto optimal alternatives (solutions). Each alternative in this set could be a solution of the multicriteria problem. In order to select one alternative, it is necessary to have additional information set by the so-called decision maker (DM). The information that the DM provides reflects his/her global preferences with respect to the quality of the alternative sought.

The systems developed to support the solution of multicriteria analysis or multicriteria optimization problems can be classified in three groups: commercial, research or teaching and experimental (for testing of new methods). The software systems supporting the solution of multicriteria analysis or multicriteria optimization problems can be divided also in two classes – software systems with general purpose and problem-oriented software systems. The general-purpose software systems aid the solution of different multicriteria analysis or multicriteria optimization problems by different decision makers. One method or several methods from one and the same group are usually realized in this kind of systems for solving multicriteria analysis or multicriteria optimization problems. The problem-oriented software systems, which support the solving of multicriteria analysis or multicriteria optimization problems, are included in other information-control systems and serve to aid the solution of one or several types of specific multicriteria analysis or multicriteria optimization problems. In this connection problem-oriented user's interface is usually realized in this kind of systems and methods from different groups of multicriteria analysis or multicriteria optimization methods are included in some of these systems.

The following general-purpose software systems are developed to aid the solution of different multicriteria problems: VIMDA, Expert Choice, PROMCALC and GAIA, ELECTRE III-IV, MACBETH, VIP, Decision Lab, Web-HIPRE, MultiChoice and KnowCube (Weistroffer et al. (2005)). Four interesting problem-oriented software systems for supporting the solving of particular multicriteria analysis problems are the following systems:

FINCLAS System - for financial classification problems, Agland Decision System – for agricultural property problems, the DESYRE System – for rehabilitation of contaminated sites, the MultCSync System – for incorporating multiple criteria in conservation planning.

Some well-known general-purpose software systems, which support the solving of multicriteria optimization problems, are the following systems: VIG, DIDAS, DINAS, MOLP-16, LBS, SOMMIX, MOIP, WWW-NIMBUS, MOLIP, NLPJOB and MOMILP (Weistroffer et al. (2005)). The Multicriteria Decision Support System for river water-quality planning and the ADELAIS System for portfolio selection are two attractive problem-oriented multicriteria optimization systems. In the class of multicriteria optimization software systems must also be included software systems, which implement different multicriteria evolutionary methods (algorithms). Four of them are the following ones: NSGM System (Srinivas and Deb (1994)), MOSES System (Coello and Christiansen (1999)), M-PAES System (Knowles and Corne (2000)) and the MOEA toolbox for MATLAB.

The paper presents some basic elements of the software system, called *MultiDecision-2*, which consist of two separate parts - the general-purpose software subsystem MKA-2, which is designed to support DMs in solving different multicriteria analysis problems and the general-purpose software subsystem MKO-2, which is designed to aid the solving of different multicriteria optimization problems. The subsystems MKA-2 and MKO-2 are described in the next two sections. Conclusions are given in the last section.

MKA-2 Subsystem

The MKA-2 subsystem, which is the first part of the *MultiDecision-2* system, is a successor of the software system MKA-1 (Genova et al. (2004)), developed in the Institute of Information Technologies – Bulgarian Academy of Sciences. The MKA-2 system operates under MS Windows operating system and it is designed to support DMs in solving different multicriteria analysis problems.

The multicriteria analysis problem may be described by a decision matrix A (n x k), which can be defined as follows:

k_j / a_i	$k_1(.)$	$k_2(.)$	…	$k_j(.)$	…	$k_k(.)$
a_1	a_{11}	a_{12}	…	a_{1j}	…	a_{1k}
a_2	a_{21}	a_{22}	…	a_{2j}	…	a_{2k}
…	…	…	…	…	…	…
a_i	a_{i1}	a_{i2}	…	a_{ij}	…	a_{ik}
..	…	…	…	…	…	…
a_n	a_{n1}	a_{n2}	…	a_{nj}	…	a_{nk}

Table 1. Decision Matrix

where a_i denotes an alternative with an index *i, i=1,…,n; and* k_j (.) denotes a criterion with an index *j, j=1,…,k.*

The evaluation of the *i*-th alternative with respect to all the criteria is given by the row vector $(a_{i1}, a_{i2}, ..., a_{ik})$. The evaluation of all the alternatives with respect to *j*-th criterion is given by the column vector $(a_{1j}, a_{2j}, ..., a_{nj})^T$.

Different methods have been developed to solve multicriteria analysis problems. A great number of the methods proposed up to now, can be grouped in three separate classes (Vincke (1992)). The first class of methods (Dyer (2004)) includes the multiattribute utility (value) theory methods (such as Value Tradeoff Method, UTA Method, MACBETH Method, Direct Weighting Method, AHP Weighting Methods). There are differences in the way in which the DM's global preferences are aggregated in the two subclasses of these methods. In the first one a generalized functional criterion is directly synthesized, whereas in the second subclass (weighting methods) it could be said that such a criterion (additive form) is indirectly synthesized. The two subclasses of methods are based on the assumption that there does not exist limited comparability among the alternatives. The second class of methods is called outranking methods (such as ELECTRE methods (Figueira et al. 2005)), PROMETHEE methods (Brans and Mareschal (2005)), etc.). They are based on the assumption that there exists limited comparability among the alternatives. In these methods one (or several outranking relation(s)) are first built to aggregate DM's global preferences, after which this outranking relation is used to assist the DM in solving the multiple criteria decision analysis problem. In most of the outranking methods it is assumed that the DM selects to

specify some preference information about inter- and intra-criteria. While the inter-criteria information is expressed in the form of weights and veto thresholds, the intra-criteria information is usually expressed in the form of indifference and preference thresholds. The interactive algorithms (such as RNIM method (Narula et al. (2003), etc.) belong to the methods of the third group. They are "optimizationally motivated" and are oriented to solve multicriteria analysis problems with a large number of alternatives and a small number of criteria.

The MKA-2 system consists of internal-system modules, four solving modules and interface modules. It is realized in MS Windows environment, including the standard for this operating system user interface elements. The internal-system modules contain all global definitions of variables, functions and procedures of general purpose. The object possibilities of Visual Basic are utilized in MKA-2 system, creating several classes with respect to internal-system structures. They are the following: a class for messages, which encapsulates the output of error messages, dynamic context help information and logging events in the debug window, localization and identification of errors occurring during the system operation; a class matrix with some specific procedures, necessary for AHP method; a class for storing the information specific for the criteria in ELECTRE III and PROMETHEE II methods and a class for storing elements of the CBIM interactive method history. MKA-2 handles files with "*.mka" extension. Standard operations for creating, editing, loading and saving of files are implemented. The MKA-2 files contain input data and data related to the process and the results from solving multicriteria analysis problems.

The solving modules realize four methods - AHP Method, ELECTRE III Method, PROMETHEE II Method and CBIM Method and procedures for transformation of qualitative, ranking and weighting criteria into quantitative criteria. AHP Method is one of the most widely spread weighting methods. Pair-wise criteria comparison is used in this method to set DM's preferences. On this basis a pair-wise comparison matrix is constructed. The estimates of the weights can be found by normalizing the eigenvector corresponding to the largest eigenvalue of this matrix. ELECTE III Method is one of the most often used outranking methods. It is based on an outranking relation, characterized by the definition of an outranking degree S (a, b) associated with each ordered pair (a, b) of alternatives, representing the more or less great outranking credibility of a over b. There are two matrix needed to be evaluated: the concordance and the discordance matrix. The concordance matrix gives an assessment of agreement that one alternative is better than other one. It requires two type thresholds - indifference and preference thresholds. The discordance matrix gives an assessment of disagreement that one alternative is better than other one. That matrix requires additional threshold, called veto threshold, which allows the outranking relation to be rejected. In order to be obtained the degree of credibility of outranking, there follows the combining the two measures from concordance and discordance matrix. This degree is thus equal to the concordance index where no criterion is discordant or where no veto threshold is used, in the opposite case. The concordance index is lowered in function of the importance of the discordance. The obtained credibility matrix is essential for generating two distillation orders that show whether one alternative outranks the other or such an alternative is incomparable to the other. In order to be obtained final ranking the two orders are combined. PROMETHEE II Method is the second of the most often used outranking methods. In this method the intensity of the preference of one alternative over another alternative regarding each criterion is measured in terms of the so-called preference function. On the basis of two type thresholds - indifference and preference thresholds - six types of preference functions are used in the method. The method provides a complete ranking of the alternatives through a pair-wise dominance comparison of net positive and net negative outranking flows. RNIM method (Narula et al. (2003)) is a representative of the interactive methods and is appropriate for solving multicriteria analysis problems with a large number of alternatives and a small number of criteria. The DM can provide desired or acceptable levels, directions and intervals of changes in the values of the criteria at any iteration. On the basis of this information, the method proposed enables the use of discrete optimization scalarizing problems, with the help of which the DM has the possibility for a more systematic and successful screening of the alternatives set.

The interface modules ensure the interaction between MKA-2 system, the DM and the operating system. This interaction includes the entry of the data for the multicriteria analysis problems; the entry of specific information for every method; the entry of information about DM's preferences; the visualization of the current results and the final result; the graphical presentation of the solutions; the printing out, reading and storing of files; the multi-language support, etc. The editing module enables entering, alteration and storing of quantitative, qualitative, ranking and weighting criteria. The interface preference modules aid the DM in the entry of criteria pair-wise comparison information, inter- and intra-criteria information and information about the desired or acceptable levels, directions and intervals of change in the values of the criteria. The current and final results and the

parameters for the separate methods selected by the DM are presented digitally and graphically with the help of visual interface modules. The input/output interface modules enable the reading and storing in files, the printing of the current and final results obtained, as well as the printing of the information, given by the DM. The solution process of a multicriteria problem can be interrupted at any stage and activated from the place of its interruption at any time. MKA-2 system has comparatively rich printing functions – every piece of the data (entered or computed) may be printed. In this way, the entire process of decision making is documented – you can review the input data of the multicriteria problem, the DM's preferences entered, the current values obtained, and the final result also, which on its turn can be printed out in the form of values or graphics. The rest of the interface modules realize a dynamic help, multi-language maintenance, etc.

Fig. 1 shows a window with information about the pair-wise comparison of the criteria for one real multicriteria analysis problem, concerning the selection of an appropriate marketing action for advertising of bicycle manufacturing company products (Brans and Mareschal (2000)). This is information about DM's preferences in operation with AHP method. Fig. 2 presents a window with information about DM's preferences in operation with PROMETHEE II method.

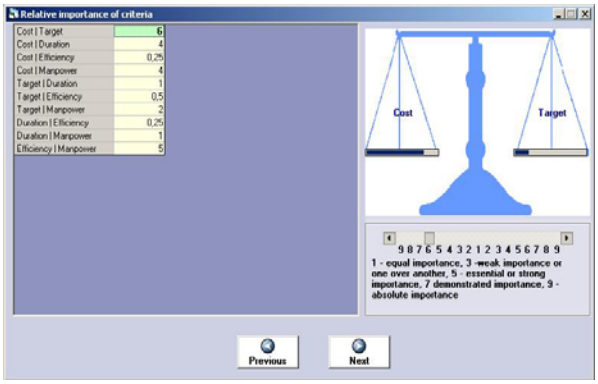

Fig. 1.

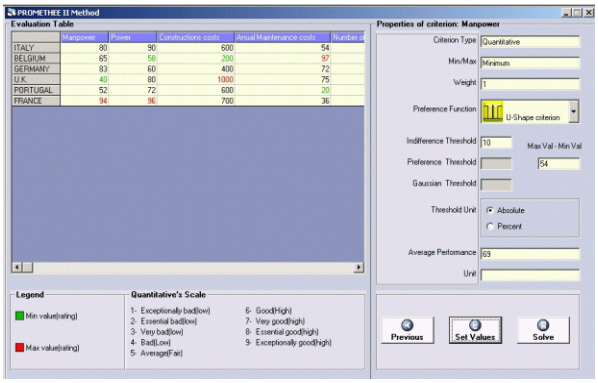

Fig. 2.

MKO-2 subsystem

The MKO-2 subsystem, the second part of the system MultiDecision-2, is a successor of the research software system MKO-1 (Vassilev et al. (2004)), developed in the Institute of Information Technologies – Bulgarian Academy of Sciences. The first version of the system MKO-2 software system is designed to aid the solution of linear and linear integer problems for multicriteria optimization only and it is oriented towards operation under the control of MS Windows operating system.

The linear and linear integer multicriteria optimization problem may be described as follows:

To optimize simultaneously the criteria:

$$\{f_k(x), \quad k \in K\}$$

subject to:

$$\sum_{j \in N} a_{ij} x_j \le b_i, \; i \in M,$$

$$0 \le x_j \le d_j, \quad j \in N,$$

x_j - integers, $j \in N'$; $N' \subset N$,

where:

$f_k(x), \; k \in K$ are linear criteria of the type: $f_k(x) = \sum_{j \in N} c_j^k x_j$;

$x = (x_1, ..., x_j, ..., x_n)^T$ is the variables vector;

$f(x) = \left(f_1(x),..., f_k(x),..., f_p(x)\right)^T$ is the vector of the criteria;

$K = \{1,2,..., p\}$, $M = \{1,2,..., m\}$, $N = \{1,2,..., n\}$ and $N' = \{1,2,..., n' / n' \le n\}$ are sets of the indices of the linear criteria, the linear constraints, the variables and the integer variables, respectively.

There are two main approaches in solving multicriteria optimization problems: a scalarizing approach(Miettinen (2003), Korhonen (2005)) and an approximation approach (Ehrgott and Wiecek.(2005)). The major representatives of the scalarizing approach are the interactive algorithms. Multicriteria optimization problems is treated in these algorithms as a decision making problem and the emphasis is put on the real participation of the DM in the process of its solution. The interactive methods are the most developed and widespread due to their basic advantages – a small part of the Pareto optimal solutions must be generated and evaluated by the DM; in the process of solving the multicriteria problem, the DM is able to learn with respect to the problem; the DM can change his/her preferences in the process of problem solution; the DM feels more confident in his/her preferences concerning the final solution.

The interactive methods of the reference point (direction) and the classification-oriented interactive methods (Miettinen (1999)) are the most widely spread interactive methods solving multicriteria optimization problems. Though the interactive methods of the reference point are still dominating, the classification-oriented interactive methods enable the better solution of some chief problems in the dialogue with the DM, relating to his/her preferences defining, and also concerning the time of waiting for new non-dominated solutions that are evaluated and selected.The generalized interactive algorithm GENWS-IM is an interactive algorithm (Vassileva (2006)) with variable scalarization and parametrization. It is a generalization of a large part of the multicriteria optimization interactive algorithms developed up to the present moment. This generalization is with respect to the classes of the problems solved, the type of the defined preferences, the number and type of the applied scalarizing problems, the strategies used in the search for new Pareto optimal solutions. Starting from the current (weak) Pareto optimal solution, the generalized scalarizing (Vassileva (2006)) problem GENWS may be used. Altering some parameters of the generalized scalarizing problem GENWS the following known scalarizing problems can be obtained: the scalarizing problem of the weighted sum WS; the scalarizing problem of ε-constraints EO; the scalarizing problem STEM; the scalarizing problem STOM; the scalarizing problem of the reference point RP; the scalarizing problem GUESS; the scalarizing problem MRP; the external reference direction scalarizing problem RD3; the classification-oriented scalarizing problem NIMBUS; the classification-oriented scalarizing problem DALDI. On the basis of the generalized scalarizing problem GENWS, a generalized interactive (Vassileva (2006)) method GENWS-IM with variable scalarizations and parameterization could be designed, having the following characteristics: the DM may set his/her preferences with the help of the criteria weights, ε-constraints, desired and acceptable levels of change of the criteria values, desired and acceptable levels, directions and intervals of alteration in the criteria values, etc.; during the process of the multicriteria problems solving, the DM may change the way of presenting his/her preferences. Starting from one and the same current Pareto optimal solution and applying different scalarizing problems (with respective alteration of GENWS), the DM may obtain different new Pareto optimal solutions at a given iteration, and this opportunity is especially useful in education and in comparison of different scalarizing problems.

A variety of methods to approximate the set of Pareto optimal solutions of different types have been proposed (Ehrgott and Wiecek (2005)). A big majority of methods are iterative and produce points or objects approximating this set. Some methods are exact equipped with theoretical proofs for correctness and optimality while some other methods are heuristic and often theoretically unsupported.The main representatives of the heuristic methods are the multicriteria genetic (evolutionary) methods (Deb (2001)), The multicriteria optimization problem is treated in these methods rather as a vector optimization problem, than as a decision making problem and the stress is placed on the determination of a subset of potential Pareto optimal solutions, which approximates well enough the whole Pareto optimal set. The solutions obtained with the help of the genetic methods, are near Pareto optimal solutions. Besides this, during the process of defining the approximating set, the DM is isolated and he/she is provided with a large set of solutions for evaluation and choice towards the end (this is a comparatively hard problem of multicriteria analysis

MKO-2 software system consists of three main groups of modules – a control program, optimization modules and interactive modules. The control program is integrated software environment for creation, processing and storing of files associated with MKO-2 system, as well as for linking and execution of different types of software modules.

The basic functional possibilities of the control program may be separated in three groups. The first group includes the possibilities to use the applications, menus and system functions being standard for MS Windows – “File”, “Edit”, “View”, “Window”, “Help”, in the environment of MKO-2 system. The second group of functional possibilities encloses the control of the interactions between the modules realizing: creation, modification and storing of files, associated with MKO-2 system, which contain input data and data connected with the process of solution of linear and linear integer multicriteria optimization problems entered; localization and identification of the errors occurring during the process of operation with MKO-2 system. The third group of functional possibilities of the control program includes the possibilities for visualization of essential information about the DM and information of the system operation as a whole. The optimization modules realize the generalized interactive method GENWS-IM, two simplex algorithms solving continuous single-criterion problems (Vanderbei (1996)), an algorithm of “branches of bounds” type for exact solution of linear integer single-criterion problems (Wolsey (1998)) and an algorithm (Vassilev and Genova (1991)) for approximate solution of linear integer single-criterion problems. The interface modules provide the dialogue between the DM and the system during the entry and correction of the input data of the multicriteria problems solved, during the interactive process of these problems solution and for dynamic numerical and graphical visualization of the main parameters of this process. With the help of an ending module the descriptions of the criteria and constraints are input, altered and stored, and also the type and limits of the variables alteration. Another interface module serves to supply two types of graphic presentation of the information about the values of the criteria at the different steps, as well as the possibilities for their comparison.

One of the main functions of MKO-2 system is to enable the extension of DM’s

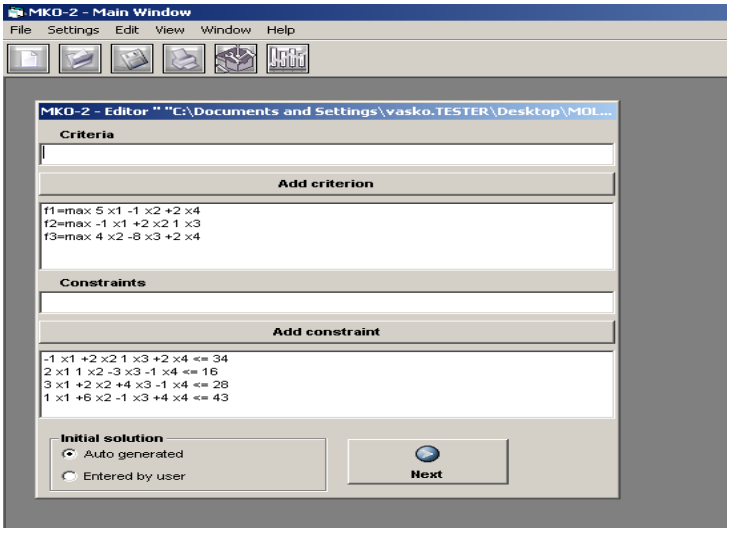

Fig.3.

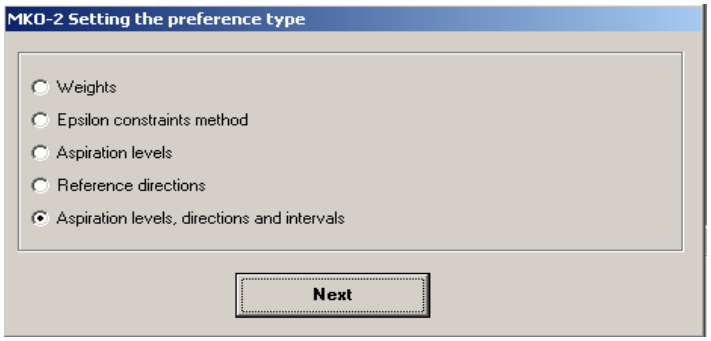

Fig.4.

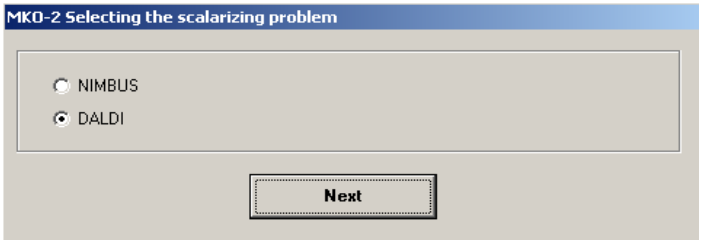

Fig.5.

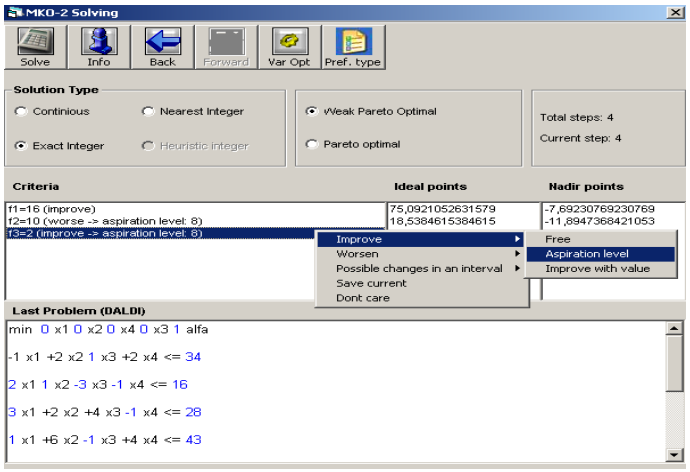

Fig.6.

possibilities to set his/her preferences with the help of criteria weights, ε-constraints, desired and acceptable directions of change of the criteria values, desired and acceptable levels, directions and intervals alteration of the criteria values. Twelve scalarizing problems are generated in MKO-2 system in order to realize these possibilities. Depending on DM's preferences, these scalarizing problems are automatically generated by the generalized scalarizing problem GENWS with the help of a change in their structure and their parameters.

MKO-2 system presents the DM different windows intended for entry and correction of the problem criteria and constraints, for setting his/her preferences. Fig.3, Fig.4, Fig.5 and Fig.6 show four of these windows. The window presented in Fig.3 is the basic window of the editor for input data entry – "MKO-2 Editor". The window presented in Fig.4, is designed to identify the type of DM's preferences. The DM may select among five types of preferences and let assume that he/she has selected to set the preferences by aspiration levels, directions and intervals. The window shown in Fig.5 is intended for selection of the scalarizing problem from the set of already known classification-oriented scalarizing problems. In order to enter the different types of DM's preferences, different windows are used. The window presented in Fig.6, is designed to enter DM's preferences with the help of desired or acceptable levels, directions and intervals of alteration in the criteria values, (operating with the classification-oriented scalarizing problem DALDI). and for solving of linear and linear integer multicriteria problems. The screen shows the setting of a new aspiration level for the value of the third criterion.

The solving of linear and linear integer multicriteria problems is realized with the help of 12 "*MKO-2 Solving*" windows, intended to work with the 12 interactive methods. Every windows "*MKO-2 Solving"* is divided into several zones. Its upper part contains a band with buttons that realize the main functions of the process for interactive solution of multicriteria linear and linear integer problems. These are the following buttons: *Solve* - for starting the optimization module in order to find a new current solution of MKO-2, solving the scalarizing problem generated at this iteration; *Info* - for visualization of the variables values at the current solution in a separate window; *Back* and *Forward* - for navigation which allow the DM to go back to preceding steps and reconsider the solutions found. The next field of "MKO-2 Solving" window contains radio buttons for setup of the type of solution looked for: continuous, integer, approximate integer, the closest integer, as well as weak Pareto optimal or Pareto optimal. Below them information is found about the time of the system operation for the current problem in seconds, the number of the step being currently considered and the total number of the executed steps.

When solving multicriteria optimization problems, it is important to provide information not only about the last solution found, but also about the solutions found at previous iterations. It is important that the DM could "testify" how he/she has reached the last solution. Hence, the information about the interactive process of the multicriteria optimization problem solving, comprising not only the problem input data, the solutions obtained at each iteration, the preferences set by the DM for a new search and the scalarizing problems constructed, stored in "*.mlp" files associated with *MKO-2* system serve not only to restart an interrupted solution process, but also for documentation.

Conclusion

MultiDecision-2 system is designed to support DMs in solving different multicriteria analysis and multicriteria optimization problems. MKA-2 system is designed to support the DMs in modeling and solving problems of multicriteria ranking and multicriteria choice. MKO-2 system is designed to model and solve linear and linear integer problems of MO. The user-friendly interface of MKA-2 and MKO-2 systems facilitates the operation of DMs with different qualification level relating to the multicriteria analysis and optimization methods and software tools. MKA-2 and MKO-2 systems can be used for education and for experimental and research problems solving as well. MultiDecision-2 system is a local multicriteria decision support system and operates in two languages – Bulgarian and English. A number of Bulgarian universities use the system for the purposes of education and for experimental and research problems solving as well. A number of official organizations and companies use the system for solving real multicriteria decision making problems. The future development of the MultiDecision-2 system will be realized in two directions. The first direction is connected with the addition of new methods. The second direction refers to web-based versions of the system, enabling distant decision making.

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DIAGNOSTIC SYSTEMS IN MEDICINE AS PERSONAL INTELLECTUAL TOOLING

Aleksej Voloshin, Maksim Zaporozhets, Pavel Mulesa

Abstract: The standards of diagnostic systems formation in medicine based on modeling expert's "means of action" in form of illegible trees of solution-making taking into consideration the criteria of credibility and usefulness have been suggested. The fragments of "applied" trees at diagnosing infectious and urological diseases have been considered as well. The possibilities of modern tooling theory usage for decision-making during creation of artificial intelligence systems have been discussed

Keywords: Decision making theory; solution trees; credibility; usefulness; diagnostic systems in medicine.

Forewords

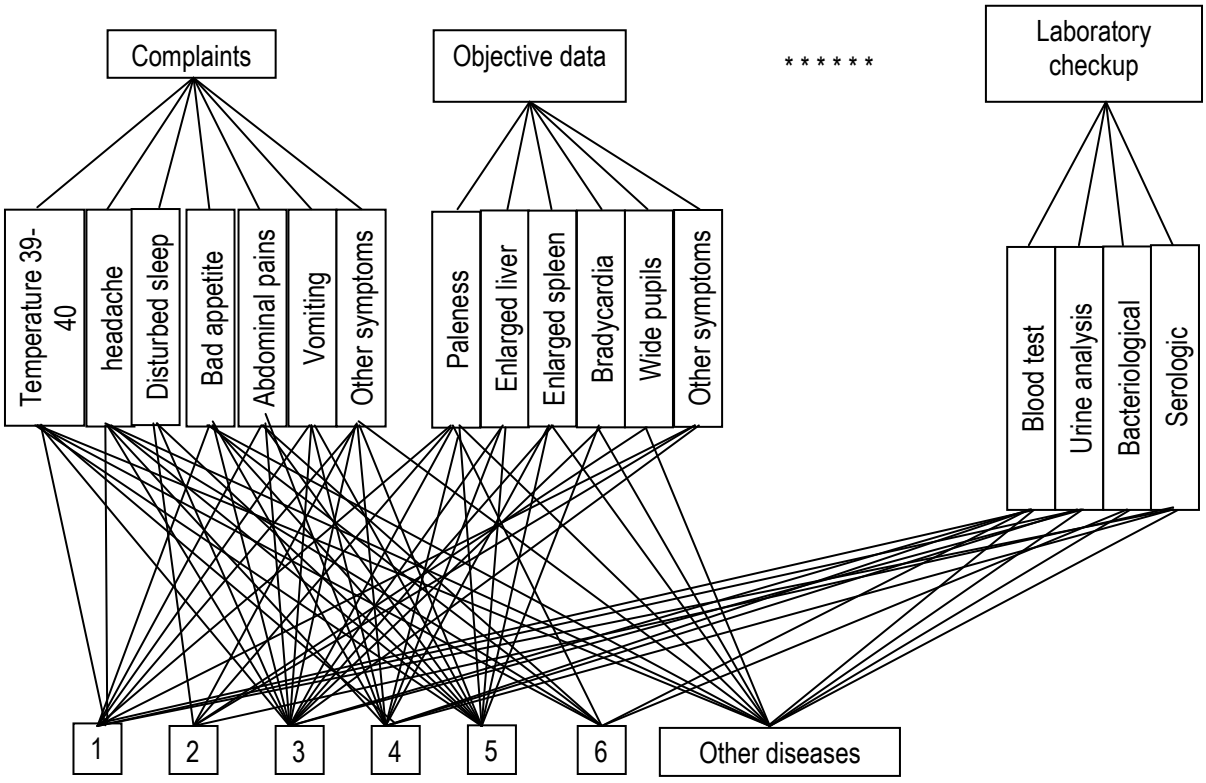
One of the first applied areas of artificial intelligence methods usage was medical diagnostics [Lyuher, 2003], [Rassel, 2006]. Elaboration of expert systems in diseases diagnostics is more than 50 years. Though the theory of decision making is a standard means in many problem areas as business, public administration, jurisprudence, military strategy, engineering design and resource management, but in the field of artificial intelligence only several investigators [Rassel, 2006, p.810] added to their arsenal the means of decision making theory in medical diagnostics. One of the main reasons for limited usage of solution trees in medicine is their "exponential size" [Rassel, 2006]. The second criterion, to our consideration (see [Voloshin, 2006]), is the incorrect usage of the "averaged" expertise. In many cases of diseases' diagnostics the "objective" ("common") criteria for assessment of factors interference intensity, that determine a disease, are lacking. The process of decision-making by a doctor-diagnostician up till now at a certain extent is subjective, and in a considerable degree depending on "intuition", "experience" and similar weakly formalized factors. And even now when the canonical program of artificial intelligence became "intellectual agent" designed to help a person [Rassel, 2006, p.1267], and replacement of an individual who is making decision, no talk about this, the role of expert system is added up to medical textbook and reference book [Rassel, 2006, p.1269]. A doctor has to realize the chain of arguments that are the root of any system solution. Otherwise the usage of artificial intelligence systems can bring to the situation when the people become more irresponsible (who will be legally responsible if the diagnosis is wrong?). That is why [Voloshin, 2006] it was suggested to switch from the conception of "expert system elaboration as "assistant" ("intellectual intensifier"), one that is making decision, to the conception of "personal tooling". And for this it is necessary to base the system on such a mode where the decision-making is committed be the user of the system. And the creator of the system has to provide the ways of this method's formalization, and at the same time for the "objectification" of the person's subjective evaluation, who is making the decision, included into the

system, it is important to consider psychosomatic peculiarities of the person who is making the decisions (in the systems of economic forecasting [Voloshin, 2005] "the experts-creator's system's subjectivity became objective"). Moreover, it is essential to provide means of subjective peculiarities account of the subject under diagnosis. As it is repeatedly noticed in the history of artificial intelligence, one of the main difficulties of the artificial intelligence system elaboration is the "extraction" of knowledge from the specialist. The task is becoming more complicated if not a "fixed" but a "dynamic" knowledge is needed ("way of thinking").

In this work is reflected the author's experience in intercourse with specialists-diagnosticians at elaboration diagnostic systems as personal intellectual tooling, fulfilling the "means of contributed action" [Lyuher, 2003] in the form of indistinct trees of solution [Voloshin, 2003]. At the same time unlike the majority of diagnostic systems in which the result of diagnostic is based on the criteria of "credibility" [Rassel, 2006], simultaneously with the evaluation of the tree arcs (factors interference), are set by impose (usefulness) of the very factors. The latter, to a certain degree, permits to avoid one of the most spread "traps" in diagnostics – confusion of credibility and significance [Rassel, 2006, p.804].

Solution Trees Formation

The tree solution method is based on the formation hierarchical structure of factors, which have direct and indirect influence on the diagnosis. In the top part of the solution tree are concentrated the main, the major factors. Further for this factors are determined sub-problems, which are influencing them. In the same way are processed the distinguished problems and etc. In the lives of this tree are included factors for which the sub-problems are not determined. For better visibility a fragment of solution tree for infectious diseases of intestinal group forecasting is shown in figure 1.



1 – salmonellosis, 2 – botulism, 3 – hepatite A, 4 – leptospirosis, 5 – typhoid fever, 6 – dysentery.

Figure 1.

Solution tree formation is led to the selection by experts the problems and sub-problems (tops of the tree) and the links between them (tree arcs). Further, the specialists define the importance (probabilities) of transitions between the tops. Indistinct evaluation of the specialists with the help of logical variables is allowed, which are described by the functions of belongings (vectors of actual numbers from 0 to 1). Each expert is giving three assessments –

optimistic, realistic and pessimistic scalarisation of which occurs while taking into account the psychological type of expert.

The tree is constructed on the basis of experts' collective evaluations with the usage of paired comparisons method. Algebraic methods of experts' information processing are used for the formation of an "effective" tree.

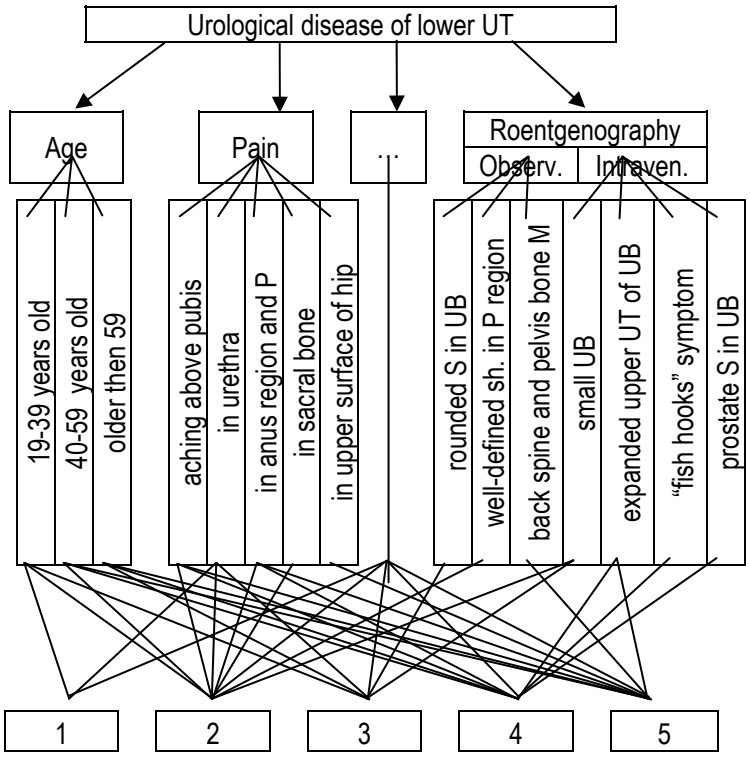
The algorithm of consecutive analysis of variants is used for the determination of optimal ways in solution trees that allows elaborating trees with thousands of peaks [Voloshin, Panchenko, 2001].

The tree of solutions is set by tables. Each table – is a separate level of the tree, each line of the table - is a separate peak\top on this level. Each element of the line is the probability of the transition from the given peak to the top of the upper level. These probabilities are set by the functions of attribute. The tables are filled in by experts questioning.

In expert way are set the matrixes – the result of tops variants' comparison, which can be inserted in the tree. On the basis of matrixes analysis are defined the tops which are included into the tree, and probabilities from which is possible the transfer into them from the peaks of the upper level.

On figure 2 is depicted a diagnostic tree of lower urinary tracts (UT) urological disease.

Note: UT – urinary tracts; P – perineum; UB – urinary bladder; M – metastases; S - shadows



1 – urethritis, 2 – prostatitis, 3 – UB stones, 4 – prostate adenoma, 5 – prostate cancer.

Figure 2.

The solution tree is examined as a graph (fig.3), a matrix of graph's tops incidence is formed, which contain the information about the weight of each top of the solution tree.

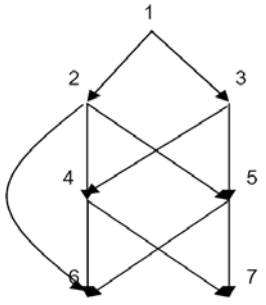


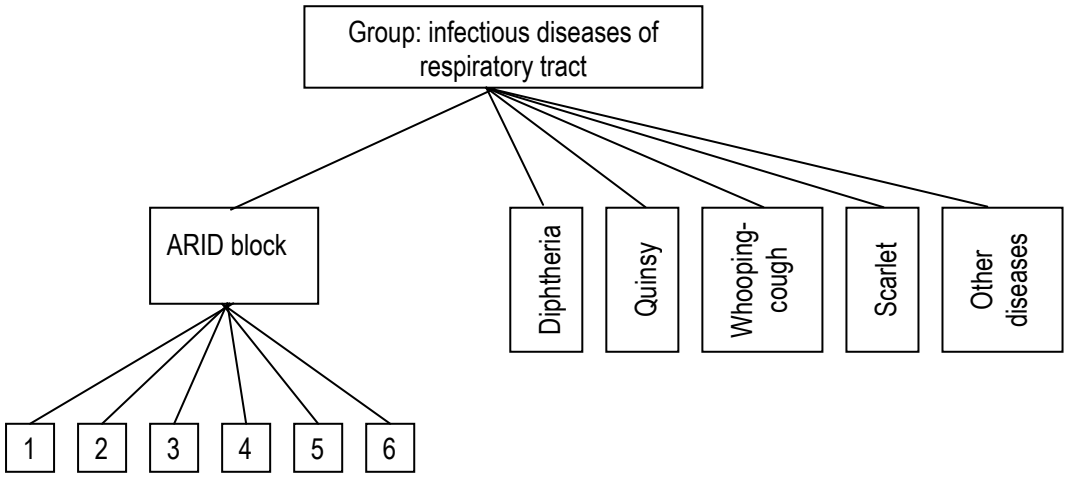
Figure 3.

System Description

At the time of decision making (diagnosing) doctor's task is to elaborate huge amount of data in a short term what is one of the components of successful diagnosing and as a result, successful medical treatment.

The solution tree in diagnosing of infectious diseases, unlike the cases observed earlier [Voloshin, Holovnya, 2005], has a multilevel structure. It is connected with the fact that the infectious diseases are divided into groups, the groups contain diseases, but some diseases make up units.

Infectious diseases are divided into five groups: intestinal infectious diseases, infectious diseases of respiratory tract, blood (transmissible) infectious diseases, infectious diseases of external tegument and infectious diseases with the parental mechanism of transmission (injection). The groups contain diagnoses, but some of the diagnoses are joined in units on the bases of symptoms similarity, extension methods and similarity of clinical presentations. For example, the unit of ARID (acute respiratory infectious diseases) contains such diseases as: influenza, parainfluenza, adenovirus disease, rhinovirus disease, respiratory syncytial disease, rheovirus disease (fig.4). For each group is formed a corresponding solution tree, the main solution tree consists of several sub-trees.



1 - influenza, 2 - parainfluenza, 3 - adenovirus disease, 4 - rhinovirus disease, 5 - respiratory syncytial disease, 6 - rheovirus disease.

Figure 4.

As it is known, a doctor in the process of diagnosis at 90% and sometimes at 100% is depending on the results of laboratory research.

Modern technological progress and scientific achievements permit with the help of laboratory research to define the photogene and the disease itself at 100%. But the doctor meets the problem - to prescribe a corresponding laboratory research. For this he needs to analyze the symptoms, which were found during the examination, and the patient's complaints concerning his or her health. That is why in a solution tree of is given a sub-tree where are defined the prescriptions of needed laboratory research.

A doctor has to be as well a psychologist in order to get more exact information, which is received, from the patient in the form of complaints. He has to define the patient's psychological type, for example, the truthfulness and the volume of complaints on his or her health.

System's Working Algorithm

First of all a doctor has to determine the method of laboratory research, the results of which are brought into the system, is defined the significance of each symptom. The program is analyzing the tree of decisions, which was created to define the methods of laboratory research and withdraw the results. After the analyses of the obtained results, into the system is put the data with new sign of significance and selection criterion. The selection criterion in this case is the pathogen itself which determines the group of infectious diseases and which is peculiar if not one, then several diseases of the same group and block. The given criterion insures the decrease in waste of time by reducing the scale of search. The system is analyzing the solution tree of the given group, which is indicated in the criterion of selection, and withdraw the results. If the result is a block (see fig.4), then the system

continues its work while analyzing only this block from the very beginning. But other choices are possible as well, when the data belongs to different groups then the system is analyzing the corresponding tree on the bases of one group's data, after this – the data that belongs to another group. The main algorithm of the system's work is shown on figure 5.

Variants Elimination Method

Whether in this case a great number of possible choices are comparatively not big, then the required result the system may achieve by means of direct surplus. But with the increase of variants' number this possibility is practically disappearing even if the PC is used.

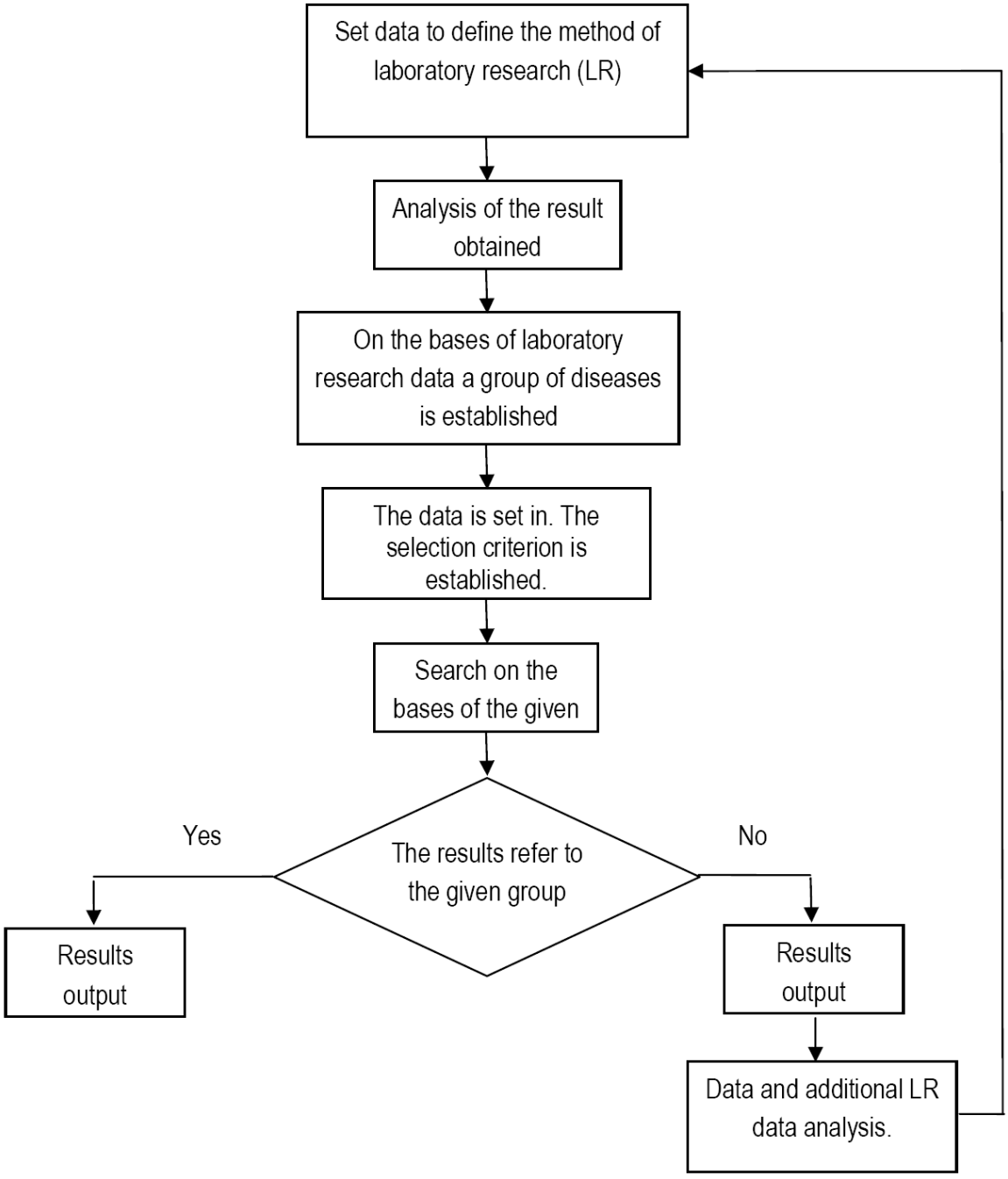


Figure 5.

Thus, arises the necessity of general methods of purposeful excess usage, which allow generating the required data during acceptable time. One of the approaches is the method of sequential variants analyses. At the heart of this method is placed the idea of the decision process presentation as a multistage structure. Each stage is connected with the examination of this or that characteristics variants subset (or separate variants) presence and leads either to the immediate shortening of the choices initial quantity, or prepare the possibility of such shortening in future. On the bases of theoretical and practical analysis of the given problem is necessary to formalize the distinctive features which are to be possessed by the required variant. Then is important to discover as far as possible more indicators which allow to determine that the given choice is not the looked for. Among these indicators are chosen the easiest tested ones and peculiar to the biggest number of variants simultaneously. After this the selection of the numerical scheme of decision lies in assignment of efficient procedure of signs examination that allows to sift out the noncompetitive variants and to find the optimum one.

From the point of view of formal logic the scheme of variants sequential analysis is reduced to the review of the following operations sequence:

- fragmentation of a quantity task solution variants on family of sub-quantities each of which possesses additional specific characteristics;
- usage of these specific characteristics for the search of logical antagonisms at description of single subsets;
- exclusion of the further variants subsets examination, in the description of which are given logical antagonisms.

At the same time the system of sequential analysis of construction and elimination of variants lies in such variants formation and operators of their analysis selection which allow to eliminate the unpromising parts of the variants without their complete construction – in proportion as this lack of any prospect is possible to detect. Since by elimination of unpromising parts of the variants simultaneously is eliminated a great number of its continuations, a considerable economy in computational procedure is taking place which is more important the more specific features of the task are used for the creation of operators of analysis and elimination [Pospelov, 1980], [Moiseev,1971].

At the beginning, the main rule of elimination of the unpromising variants was the principle of monotonous recursiveness, which is cognate to the criterion of optimal dynamic programming [Bellman, 1960]. On the basis of this principle algorithms of step-type variants construction were created for different tasks solution of discrete optimization [Mikhalevich, Shkurba, 1966].

Along with the known values the algorithms of step-type solutions construction possesses as well certain disadvantages. Thus, they, as a rule, make great demands from the on-line storage of PC and determine, with the number growth of task limitation, the drastic increase of calculating work volume for optimizing. These facts are confirmed by computing experiments as well by theoretical estimate.

At the same time the very procedure of sequential variants analysis allows to create common schemes of discrete optimization tasks solution, which differs from the dynamic ones (i.e. based on step-type decisions construction). The refusal from the idea of step-type decisions construction at tasks solution with the method of sequential analysis and variants elimination leads to the necessity of organizing the sub-variants analysis procedure. Thereby disappears the necessity to choose the “principles” of partial decisions development and is eliminated the “dissymmetry” in analysis of decision component. As well is eliminated the need to remember all the time a quantity of “not dominating” partial decisions that are developed at the next step [Volkovich, Voloshin,1984].

At the heart of sub-trees analysis methods into the system is placed the described above decomposition method of alternative variants retrieval [Voloshin, 1987].

Conclusion

The authors do not know the usage facts of the current achievements in the theory of decision-making in medicine, though for their usages in other fields, first of all in economics, over the last years were given two Nobel Prizes.

While implementing the idea of "object – action manner – subject" interaction [Voloshin,2006] is advisable to consider the diagnosis establishment task as a task of collective decision making [Voloshin, Vaschenko, 2006] in whish the "efficient" agents are - "patient – expert diagnostic system – doctor". It is advisable in some cases, obviously, to enlarge the number of agents, e.g. of "pharmacist" (purposes his or her aims, frequently antagonistic for the patient). And here are possible completely other "optimizing principles", that differ from "utility maximization taking into consideration the probabilities" [Rassel, 2006].

It is not excluded that the compromise in "life" is achieved as realization of "Nash's optimization principles" [Voloshin, Maschenko, 2006] – a solution is chosen (consciously or unconsciously), from which it is disadvantageous to deviate both for all agents together, as well as for each separately.

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AN INTELLIGENT SYSTEM FOR INVESTIGATIONS AND PROVISION OF SAFETY FOR COMPLEX CONSTRUCTIONS

Alexander Berman, Olga Nikolaychuk, Alexander Yurin, Alexander Pavlov

Abstract: Methodology of computer-aided investigation and provision of safety for complex constructions and a prototype of the intelligent applied system, which implements it, are considered. The methodology is determined by the model of the object under scrutiny, by the structure and functions of investigation of safety as well as by a set of research methods. The methods are based on the technologies of object-oriented databases, expert systems and on the mathematical modeling. The intelligent system's prototype represents component software, which provides for support of decision making in the process of safety investigations and investigation of the cause of failure. Support of decision making is executed by analogy, by determined search for the precedents (cases) with respect to predicted (on the stage of design) and observed (on the stage of exploitation) parameters of the damage, destruction and malfunction of a complex hazardous construction.

Keywords: computer-aided investigations, intelligent system, technical state, safety, construction, malfunction, failure, case-based reasoning.

ACM Classification Keywords: I.2.1 Applications and Expert Systems: Medicine and science, Industrial automation

Introduction

Prevention of failures in industry necessitates solution of the problem of investigation and provision of technogenic safety on all the stages of the life cycle of complex constructions: beginning from the design, construction engineering, manufacture and ending with application and utilization. The problem of safety investigations is a multi-disciplinary one. For the purpose of its solution it necessitates that knowledge and the potential of the following scientific disciples be involved: physics and mechanics of destruction, physics-chemical mechanics of materials, material engineering, reliability and safety of technologies and constructions, toxicology, foundations of design, technology of mechanical engineering, psychology, mathematics, information technologies, etc. Safety is substantially dependent on the efficiency of the systems intended for estimation and forecasting of the technical state and resource, precision of diagnostics and correct determination of the causes safety violations.

Investigation of incidents and failures, which implies description of the total cause-effect complex of their formation, is one of the main sources for acquisition of knowledge about hazards and their development [Berman, 1998].

In connection with the multi-disciplinary character of the problem of investigation and amplification of construction safety, it is necessary to provide for a coordinated activity of the researchers and the specialists, who regulate different stages of the complex systems' life cycle. This may be achieved only via elaboration of the respective computer-aided technologies intended for automation of research, which is conducted within the frames of an integrated intelligent information system and on the basis of accumulation, modeling, initial processing and efficient application of diverse information and knowledge [Berman at all, 1999].

Methodology of information support and automation of research related to technogenic safety

The methodology of computer-aided research and provision of safety properties is determined by the object's model, by the structure and functions of the process of investigation, and by the set of methods employed in the investigation.

Object's Model. Investigation and development of the recommendations related to provision of safety is based on identification and application of the regularities of the genesis, generation and development of the hazards independently of the functions and the structure of construction.

Correct determination and prediction of the causes allow us to make the objects more perfect, ground some necessary modernization, redefine the periodicity, the methods and aids needed for diagnostics and monitoring, ground the undertakings related to prevention of failures and provision of safety in case of their occurrence.

To the end of investigation of the causes of occurrence of hazardous states, we have proposed a cause-and-effect complex which determines their occurrence in the form of a model of dynamics of undesired processes. A block-diagram of dynamics of this process is shown in Fig.1. Each sequential state is conditioned by the previous one and is characterized by the some larger hazard. So, since presently our knowledge bound up with understanding sufficiency of the measures and undertakings needed for provision of reliability and safety is limited and the systems, which are intended to maintain reliability of operation and safety, are hardly ever fail-safe, malfunctions of such systems take place and provoke failures.

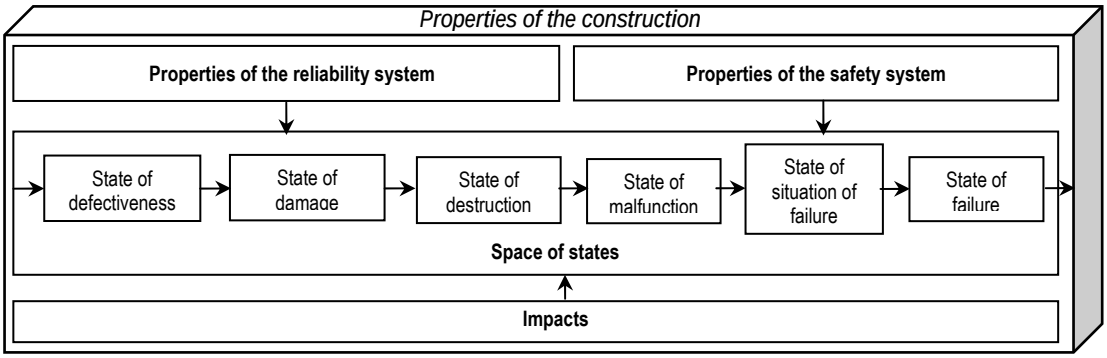

Figure.1. The cause-and-effect complex of state dynamics for the construction

According to this model, hazardous states are conditioned by properties of the designed system, by the character of impacts and by properties of systems intended to provide for reliability and safety. System's properties are characterized, for example, by i) the number of new system's components and ii) the degree of their uncertainty, iii) predictability of development of the states, iv) the level of hazard for the substances either processed or transported, v) the degree of hazard for the technological process parameters. The properties of impacts include those of mechanical, physical-chemical and biological influences, which violate safety; the rate of their development and distribution; the degree of their effect on the safe state. Properties of the safety system include, for example, observability; controllability; opportunity of state monitoring, which implies real-time information processing and realization of adequate measures for planning hazards; survivability, e.g. the operating time from the moment of occurrence of a hazardous state to the moment of transition onto another level of the hazardous state.

The structure and functions of the process of investigation. The process of investigation has a hierarchical structure. The structure of the process of investigation is conditioned by the following factors:

- the structure of the object under scrutiny: part – unit of an assembly – construction;
- the proposed structure of the state space: defect – damage – destruction – malfunction – situation of failure – failure [Berman, 1998; Berman at all, 2007];
- a set of mechanisms of occurrence and a variety of hazards which are the causes of safety violation;
- a set of scenarios bound up with development of each hazard;
- a set of variants of decisions bound up with provision of safety properties which satisfy the conditions of an acceptable risk.

The proposed structure of the model of the cause-and-effect complex is the decisive factor defining the scheme of investigation which includes consecutive investigation stages concerned with all the phases of states – from the appearance of a defect to the formation of failure. On each stage the factors are revealed, which condition and influence the frequency and consequences of hazardous states. This is necessary for the purpose of determination of the construction's rational preventive, control and protective properties, which are generalized in the concept of "property of safety". Methods and aids of provision of these properties are based on the results of such investigations.

Functions of the process of investigations correspond to the stages of decision making needed for achievement of the objectives bound up with provision of acceptable risk for all the kinds of hazardous states of constructions (Fig.2).

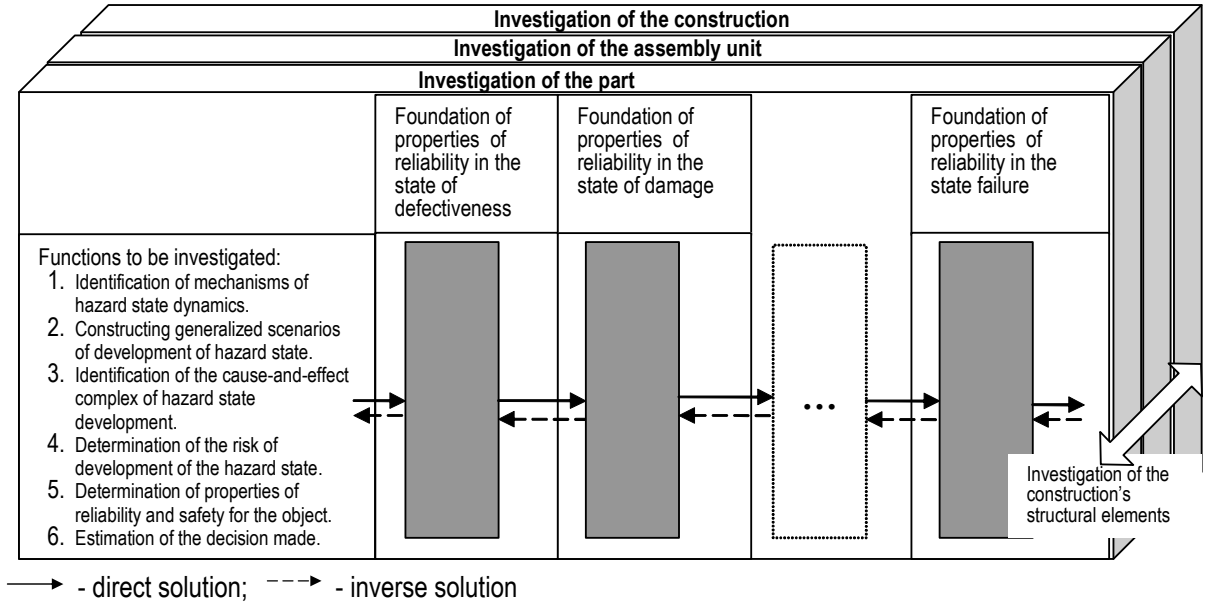

Fig.2. The structure of the process of investigation.

Methods of Investigation. In accordance with the methodology proposed, the process of investigation and provision and maintenance of safety for complex constructions is conducted with the aid of a set of methods based on the technologies of object-oriented databases, expert systems and mathematical modeling.

The process of investigation is provided by combining the methods (see Fig.3): case-based and rule-based expert systems, ontologies, methods of analytical modeling [Aamodt at all, 1994; Berman at all, 2004; Luger, 2002; Portinale at all, 2004]. In turn, before applying above methods it is necessary to perform modeling (redefining, constructing a thesaurus) of the problem domain.

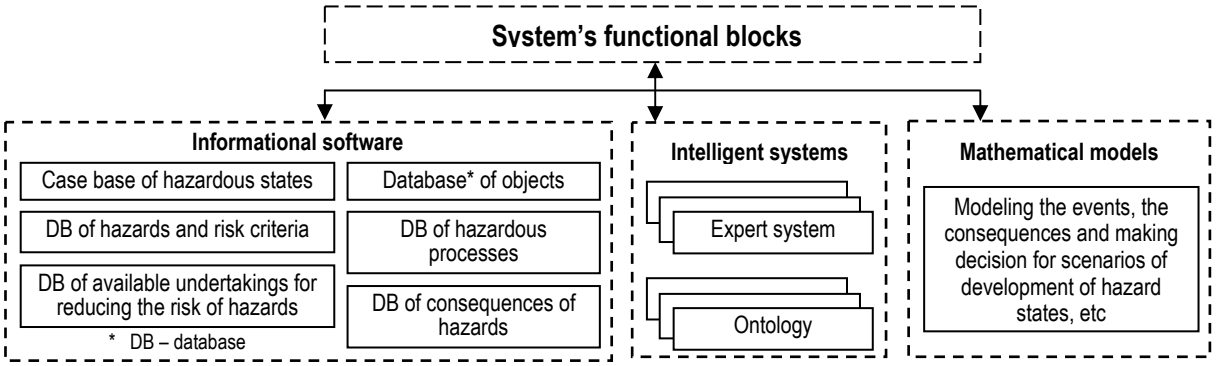

Figure.3. The architecture of the system for investigation and provision of reliability and safety of the constructions.

Ontological systems belong to the most contemporary forms of information (data and knowledge) representation (Berman at al., 2004b). The principal intention of the ontology implies formalization and integration of information. Ontology facilitates structuring and modeling weakly-formalized problem domains. Being grounded on the general set of terms, it determines and simplifies the semantics of formal information, facilitates its computer processing, while representing the information in the form convenient from the viewpoint of perception.

Application of the mechanism of ontology in problems of providing safety of constructions is conditioned by insufficient formalization and multi-disciplinary character of the problem under scrutiny. Its solution necessitates application of knowledge in science of materials, solid body physics, physics and mechanics of destruction, physical and chemical mechanics and strength of materials, monitoring, diagnostics and forecasting, theories of risk and safety. Furthermore, likewise in all multidisciplinary investigations, there exists the problem of knowledge coordination and development of a uniform conceptual apparatus which would provide for efficient interaction between the researchers involved in different fields of knowledge.

So, first of all, it is necessary to construct an ontology (a dictionary-type ontology) of construction safety and then formalize the main concepts from the viewpoint of the cause-and-effect complex of safety violation.

The formalized concepts form a taxonomy of concepts which inherit the properties of general concepts. Such abstract concepts as defect, damage, destruction, malfunction, situation of failure, failure have been decomposed into definite concepts. The ontology elaborated is supposed to be used as a knowledge base for the system proving for safety.

Case-based reasoning provides for solving the problems on the basis of precedents (cases), while using accumulated experience, i.e. the decisions made earlier [Aamodt at all, 1994]. According to this methodology, the process of solving the problem represents a sequence of stages related to finding (retrieval) some analogs and reuse of the information contained in them.

Furthermore, knowledge (apparatus) of different scientific and engineering disciplines is concentrated with respect to these precedents. So, each precedent represents some systematized and classified information on the causes of possible or actual damages and destruction of the construction, which condition either probable or actual (real) violation of safety (failure).

The precedent includes the following information: project and actual exploitation conditions; a sequence of the states, which could lead to the state under scrutiny, while including the properties of these states; causes of the state; the organizing-technical genesis of the state; the structural genesis of the state; consequences of the state; the decision made to prevent the undesirable state; etc.

The construction has a hierarchical structure, each element of which is characterized by a state. The relation "part–total" between the structural elements conditions the cause-effect relations between their technical states: a part, which represents an element of an assembly unit, may be the cause of the undesirable state for the assembly unit; etc.

Proceeding from this assumption, it is possible to state that there exists a hierarchical space of precedents. Furthermore, each precedent (case) corresponds to a set of indices, which represent a brief description of one of the declarative aspects of the precedent: for example, either structural belonging of the object (involved in the incident) or its technical state. Depending on the complexity of description (some available hierarchy of properties and a type of criteria: determined/logical) the indices (descriptors) represent either binary sequences (…01001…) or some sets of corteges ({..., P_i , ...}, $P_i = \langle n, v, w, r \rangle$, where n is the property's name; v is its value; w is the importance (or information weight) of the property; r is the restriction imposed on the band of values – the restriction determines the band of values within the frames of which the property's value can determine the value of the measure of similarity; in the case when the property's value occurs outside of this band of values the value of the similarity measure is 0).

Presence of the given set of indices allows us to apply elements of the procedure of sequential solutions [Zhuravlev at all, 1989] in the process of finding solution. Finding (retrieval) of the precedents with respect to separate indices and groups of indices (from the set of indices) allows one not only to substantially increase the search algorithm's computational power (and, therefore, complexity of the process of investigations) at the expense of restricting the number of vain (irrelevant) comparison and search operation, but also to concentrate attention of the researcher on some important aspects of the technical state dynamics.

Selection of precedents on each of the stages in the procedure of sequential solutions is conducted in accordance with a global measure (estimate) of similarity/closeness of descriptions of the precedents. This measure is computed as a distance between the precedents in the space of criteria (features). The distance is computed using both the Minkovsky metrics [Bergmann, 2002] (1), which is a generalization of the so called "city district metrics" (which is used in processing of binary vectors) and the Euclidean distance (used in processing some sets of corteges):

$$dist_{Minkowsi,p}(\bar{x},\bar{y}) = (\sum_{i=1}^{n}|x_i - y_i|^p)^{1/p} \quad (1)$$

The parameter p determines whether it behaves like the so called "city district metrics" ($p=1$) or like the Euclidean distance ($p=2$).

The search within a hierarchical space may be both ascending (bottom – up) (i.e. from a part to a construction) and descending (top to bottom). In the first case, the problem of forecasting is solved in the process of investigation; in the second cease, the problem of genesis is solved.

Consider the sequence of stages (steps) in the search algorithm intended for finding precedents in the process of solving the problem of genesis. This problem can be solved on the stage of exploitation of the object, when some malfunction of the construction has already taken place, external manifestations of the malfunction are obvious, and it is necessary to find out the causes of this malfunction.

Step 1. The user describes the object of investigation, i.e. the failed construction, while taking into account initial exploitation conditions (values) and external manifestations of malfunction, and then automatically forming the initial set of indices needed for the description.

Next, search for the analogs with respect to the indices, which describe structural belonging of the failed construction and external manifestations of malfunction is sequentially conducted. The result of the procedure of finding (retrieval) is a list of similar precedents ordered according to the estimate of closeness (similarity) of the descriptions. This list allows one to analyze the malfunctions having similar indicators and make a preliminary decision related to investigation of causes of the malfunction, for example, a decision on testing all the assembly units (or parts), which have been indicated in the list as possible causes of malfunction.

Step 2. Having obtained additional information in the form of a list of similar construction malfunctions, the user continues the process of investigation – determines the genesis of the malfunction. The structural genesis of malfunctions of all constructions is the malfunction of one of the assembly units (or parts) included in some or another construction. A set of possible structural genesises of construction's malfunctions is formed in the process of investigation of these assembly units (parts). The procedure of finding (retrieval) proceeds to the next level in the hierarchy of the space of precedents (cases), to the level of precedents describing the malfunctions of assembly units (or parts).

In turn, already on the given level, there takes place the search of analogs with respect to external manifestations of some malfunction, the result of which are some precedents containing the description of the most probable cause of the malfunction for the assembly unit. Having chosen the most close description of the malfunction (and, consequently, the most probable failed assembly unit), the user redefines the actual conditions of its exploitation and external manifestations of its malfunction.

Step 3. Since the object of investigation represents itself a hierarchical structure, and the process of investigation represents a sequential and goal-oriented search of analogs in the hierarchical space of precedents, after finding the analogs at the level of precedents, which describe malfunctions of assembly units, there follows the search for the precedents at the next level, i.e. at the level of precedents, which describes malfunctions of parts. At the given level, the search (retrieval) of analogs is conducted with respect to the indices, which describe external manifestations of damage, destruction and malfunction of the part, and on account of information of actual conditions of its exploitation and initial defectiveness (conditioned by the technology of manufacture). Such a description of this step is given in [Nikolaychuk at al, 2006].

Only on the given step the user reaches the beginning of the chain of the structural genesis of malfunction and obtains the possibility to "assign" and analog, i.e. to choose the most close precedent. As a result of this "assignment", attribution of the solution, which is contained in the analog, to a new precedent, which characterizes the current situation, takes place. The solution contains a description of the organizing-technical causes of malfunction for the part as well as a description of undertakings, which are needed to prevent any malfunctions of the part in future.

Step 4. As soon as the cause of the part's malfunction has been determined, the algorithm turns back to the stage of finding out the malfunction for the assembly unit. On this stage, the organizing-technical genesis of malfunction of the part is inherited by the assembly unit. The part in the structural genesis is fixed, which caused the malfunction of the assembly unit. Noteworthy, after "assigning" the analog, we obtain the total chain of the cause-effect complex in the form of a set of precedents: the part's precedent – the assembly unit's precedent – the construction's precedent. On each of the levels, the precedent contains information on the cause of malfunction

and the undertakings needed. So, the undertakings, which need to be conducted for the assembly unit, are inherited from a similar precedent of malfunction for some assembly unit and are redefined by the user on account of the definite characteristics of the problematic situation.

Step 5. As soon as the cause of the assembly unit's malfunction has been determined, the algorithm turns back to the stage of finding out the malfunction for the construction on the whole. On this stage, the organizing-technical cause of malfunction of the assembly unit is inherited by the construction. The assembly unit in the structural genesis is fixed, which caused the malfunction of the construction. The undertakings, which need to be conducted for the construction, are inherited from a similar precedent of malfunction for some other construction and are redefined by the user on account of the definite characteristics of the problematic situation.

Therefore, it appears possible to determine (trace) the whole chain of genesis for the malfunction. Before the moment of "assigning" an analog, the user can turn back to the previous step, input additional information and repeat the search (retrieval) of analogs.

Application of analogs in many cases necessitates adaptation of available solutions, what may be implemented by the concretization, which implies qualitative redefining the description of the precedent, refining the parameters and their values.

The problem of genesis of states for a failure situation or a failure is solved by the case-based method likewise in the problem of genesis of construction malfunction considered above.

The rule-based reasoning provides for solving problems of investigation on the basis of models of the cause-effect complex of occurrence of malfunctions and failures. A corresponding rule-based model has been developed, where the object concepts and relations between them have been transformed into the production rules of CLIPS [Nikolaychuk at all, 2006].

The mathematical models. In the problem domain under scrutiny, side by side with weakly formalized knowledge, there are separate aspects of the technical state dynamics which are described by analytical models, for example, by models of growth of micro-cracks, variation of material hardness, variation of residual stress (strains) in the part, etc. So, in the process of describing the process of variation of the technical state, it is necessary to combine rule-based models (and/or case-based model) and analytical models, when the latter complement and redefine the values of separate parameters of these knowledge models.

Application (Intelligent System)

Implementation of the system is conducted by component-wise assembly of the systems designed by the team [Berman at all, 2006]. Each component represents an autonomous module having some internal memory and a unified interface. The internal memory provides the user with the opportunity to input some information needed for modification of the basic functionality, its adjustment to the specificity of a definite problem domain. The unified interface represents a set of properties and the methods needed for obtaining a description of a component and for controlling it.

In the process of design of these components it was necessary to isolate the employed knowledge of some problem domain from the knowledge of the object domain; the component has to know "how" the information is processed, but not "what" is definitely processed. When some purchased software is employed, the implementation of a component consists in design of a controlling module for this software. The unified interface gives the possibility of programmed control of a component, what provides for the possibility of dynamic integration of the system's components into a joint system.

Presently, we have elaborated a prototype of intelligent system intended for determination of causes of malfunctions and failures in the oil-chemical industry [Berman at all, 2006], which includes the following components: component for modeling (description) of an object domain, which provides for integration of the information on the object domain [Berman at all, 2004a]; case-based and rule-based expert systems [Nikolaychuk at all, 2006]; modules, which implement mathematical functions. Furthermore, there are databases, which contain information on the constructions, degradation processes, consequences and undertakings oriented to neutralization of the impact. The knowledge base of the case-based expert system contains information on 250 malfunctions and failures which have taken place at different oil-chemical enterprises. The rule base of the rule-based expert system includes the rules for the relationships between degradation processes, causes and the related undertakings. Mathematical models intended for computing the rate of cracking development and corrosion have been developed.

Conclusion

Provision of predicted technical state, estimation of the possible hazard of the object's destruction and the expected damages (detriment) acquires special importance at the stages of design of technical devices intended to be applied under special, extreme conditions, for example, under water or in space. It acquires importance also in connection with the necessity of all the more increased degree of automation and informatization of all the life cycle stages of complex constructions performed on the basis of adaptive and intelligent control systems.

Development of computer-aided systems of automation and informatization of research, which imply storage, initial processing, modeling and efficient application of diverse information and knowledge within the frames of one integrated intelligent information system, ensures coordinated activity of researchers and specialists in solving multi-disciplinary problems of investigation and increase of safety of the complex constructions on various stages of their life cycle.

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OPTIMIZATION OF THE INVESTMENT PORTFOLIO IN THE CONDITIONS OF UNCERTAINTY

Yurii Zaychenko, Maliheh Esfandiyarfard

Introduction

Portfolio analysis exists, perhaps, as long, as people think about acceptance of rational decisions connected with use of the limited resources. However the occurrence moment of portfolio analysis can be dated precisely enough is having connected it with a publication of pioneer work of Harry Markovittz (Markovitz H. Portfolio Selection) in 1952. The model offered in this work, simple enough in essence, has allowed catching the basic features of the financial market, from the point of view of the investor, and has supplied the last with the tool for development of rational investment decisions.

The central problem in Markovitz theory is the portfolio choice that is a set of operations. Thus in estimation, both separate operations and their portfolios two major factors are considered: profitableness and risk of operations and their portfolios. The risk thus receives a quantitative estimation. The account of mutual correlation dependences between profitablenesses of operations appears the essential moment in the theory. This account allows making effective diversification of portfolio, leading to essential decrease in risk of a portfolio in comparison with risk of the operations included in it. At last, the quantitative characteristic of the basic investment characteristics allows defining and solving a problem of a choice of an optimum portfolio in the form of a problem of quadratic optimization.

However the worldwide market crises in 1997-1998 and in 2000-2001, which had yielded only to the American investors 10 billion dollar losses, have shown, that existing theories of optimization of share portfolios and forecasting of share indexes have exhausted itself, and essential revision of share management methods is necessary.

Thus, in the light of obvious insufficiency of available scientific methods for management of financial actives, the development of fundamentally new theory of management of the financial systems functioning in the conditions of essential uncertainty needed. The big assistance to this theory was rendered by the theory of the fuzzy sets which have been developed about half a century ago in fundamental works of Lofti Zadeh.

The purpose of the present work is research and the analysis of qualitatively new approach to management of the share portfolio, based on application of the theory of fuzzy sets, and also development of algorithms realizing the given approach and comparison of results of their application with the results received at use of classical probabilistic methods.

Problem statement

The purpose of the analysis and optimization of an investment portfolio is research in area of portfolio optimization, and also the comparative analysis of structure of the effective portfolios received at use of model Markovitz and fuzzy-set model of a share portfolio optimization.

Let us consider a share portfolio from *N* components and its expected behaviour at time interval $[0, T]$. Each of a portfolio component is characterized $i = 1,..., N$ by the financial profitableness r_i .

The holder of a share portfolio – the private investor, the investment company, mutual fund – operates the investments, being guided by certain reasons. On the one hand, the investor tries to maximise the profitableness. On the other hand, it fixes maximum permissible risk of an inefficiency of the investments. We will assume the capital of the investor be equal 1. The problem of optimization of a share portfolio consists in a finding of a vector of share price distribution of papers in a portfolio $x = \{x_i\}\ i = \overline{1, N}$ of the investor maximising the income at the set risk level (obviously, that $\sum_{i-1}^{N} x_i = 1$).

Weaknesses of accurate model Markovitz

In process of practical application of model Markovitz its lacks were found out:

1. The hypothesis about normality profitableness distributions in practice does not prove to be true.

2. Stationarity of price processes also not always is in practice.

3. At last, the risk of actives is considered as a dispersion standard deviation of the prices of securities from expected value i.e. as decrease in profitableness of securities in relation to expected value, and profitableness increase in relation to an average are estimated absolutely the same.

Though for the proprietor of securities these events are absolutely not the same.

These weaknesses of Markovitz theory define necessity of use of essentially new approach of definition of an optimum investment portfolio.

Fuzzy sets method of portfolio optimization

Main principles and idea of a method

The risk of a portfolio is not its volatility, but possibility that expected profitableness of a portfolio will appear below some preestablished planned value.

- Correlation of assets in a portfolio is not considered and not accounted.
- Profitableness of each asset is not random fuzzy number. Similarly, restriction on extremely low level of profitableness can be both usual scalar and fuzzy number of any kind. Thus, we reduce two sources of the information (average profitableness and volatility of asset) in one (a settlement corridor of profitableness or the price) and by that unite two sources of uncertainty into one.
- Therefore optimize a portfolio in such statement may mean, in that specific case, the requirement to maximize expected profitableness of a portfolio in a point of time T at the fixed risk level of a portfolio
- Profitableness of a security on termination of ownership term is expected to be equal r and is in a settlement range. For i-th security:

$\overline{r_i}$ – expected profitableness of i-ой security;

r_{i1} – the lower border of profitableness of i-th security;

r_{i2} – the upper border of profitableness of i-th security.

$r_i = \left(r_{1i}, \overline{r_i}, r_{2i}\right)$ – profitableness of i-th security, is triangular fuzzy number.

Then profitableness of a portfolio:

$$r = (r_{\min} = \sum_{i=1}^{N} x_i r_{1i}; \overline{r} = \sum_{i=1}^{N} x_i \overline{r_i}; r_{\max} = \sum_{i=1}^{N} x_i r_{2i}) \quad (9)$$

where x_i - weight of i-th asset in portfolio, and

$$\sum_{i=1}^{N} x_i = 1, \qquad 0 \le x_i \le 1. \quad (10)$$

Critical level of profitableness of a portfolio at the moment of T may be fuzzy triangular type number $r^* = \left(r_1^*; \overline{r}^*; r_2^*\right)$.

Mathematical model of optimization of an investment portfolio by means of fuzzy sets

Let us consider a risk estimation of portfolio investments. On fig. 1 membership function r and criterion value r^* are shown

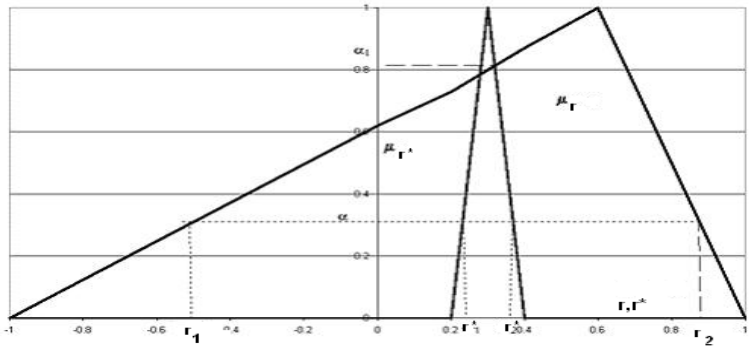


Fig. 1. Membership functions of *r* and *r**

Point with ordinate α_1 - the crossings point of two membership functions .Let us choose any level of membership α and define corresponding intervals $[r_1, r_2]$ and $[r_1^*, r_2^*]$. At $\alpha > \alpha_1$, $r_1 > r_2^*$, intervals are not crossed, the risk and inefficiencies level equals to zero. Level α_1 top border of risk zone. At $0 \le \alpha \le \alpha_1$ intervals are crossed.

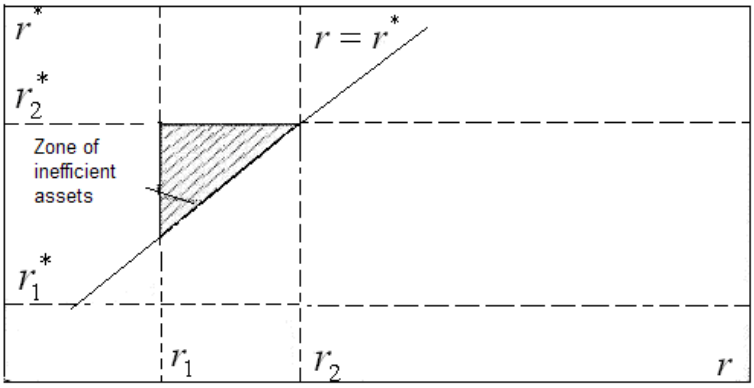


Fig. 2. Phase space (r, r^*)

$$S_\alpha = \begin{cases} 0, \ if \ \ r_1 \ge r_2^* \\ \dfrac{(r_2^* - r_1)^2}{2}, \ if \ \ r_2^* > r_1 \ge r_1^*; \ r_2 \ge r_2^* \\ \dfrac{(r_1^* - r_1) + (r_2^* - r_1)}{2} \cdot (r_2^* - r_1^*), \ \text{if } r_1 < r_1^*, \ r_2 > r_2^* \\ (r_2^* - r_1^*)(r_2 - r_1) - \dfrac{(r_2 - r_1^*)^2}{2}, \ if \ \ r_1 < r_1^* \le r_2; \ r_2 < r_2^* \\ (r_2^* - r_1^*)(r_2 - r_1), \ \ if \ \ r_2 \ge r_1^* \end{cases} \quad (11)$$

Where S_α are shaded areas of flat figure. Since all realizations (r, r^*) at set membership level $\varphi(\alpha)$ equally possible, so the degree of inefficiencies risk $\varphi(\alpha)$ geometrical probability of event of hit of a point in (r, r^*) to the zone of inefficient distribution of the capital []:

$$\varphi(\alpha) = \frac{S_\alpha}{(r_2^* - r_1^*) \cdot (r_2 - r_1)}, \quad (12)$$

total value of risk level of portfolio inefficiency:

$$\beta = \int_0^{\alpha_1} \varphi(\alpha) \partial \alpha \quad (13)$$

when the criterion of efficiency is defined accurately level, r^* limiting transition at $r_2^* \to r_1^* \to r^*$ gives:

$$\varphi(\alpha) = \begin{cases} 0, \ if \ \ r^* < r_1 \\ \dfrac{(r^* - r_1)}{(r_2 - r_1)}, \ \ if \ \ r_1 \le r^* \le r_2; \ \alpha \in [0;1]. \\ 1, \ if \ \ r^* > r_2 \end{cases} \quad (14)$$

For risk estimation are necessary:

1. two values of inverse function $\mu_r^{-1}(\alpha_1)$: r^*, $\tilde{r}^*$.

2) two values of inverse function $\mu_r^{-1}(0)$. $r_{\min}$, $r_{\max}$

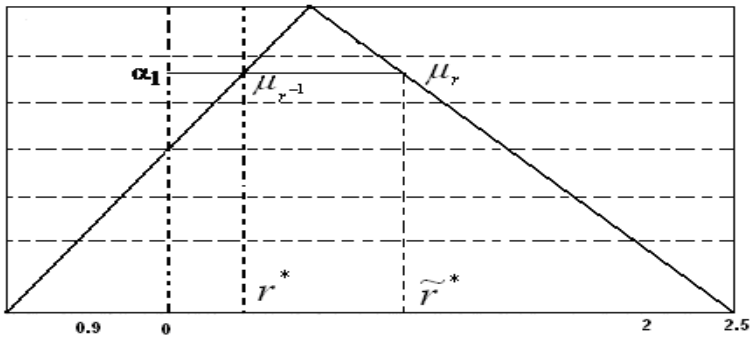


Fig. 3. An example of non-fuzzy efficiency criterion $\tilde{r}$

- The most expected value risk degree of a portfolio β:

$$\beta = \begin{cases} 0, \ npu \ \ r^* < r_{\min} \\ R\left(1 + \dfrac{1-\alpha_1}{\alpha_1}\ln(1-a_1)\right), \ if \ \ r_{\min} \le r^* \le \tilde{r} \\ 1 - (1-R)\left(1 + \dfrac{1-\alpha_1}{\alpha_1}\ln(1-a_1)\right), \ if \ \ \tilde{r} \le r^* < r_{\max} \\ 1, \qquad\qquad\qquad\qquad , \ if \ \ r^* \ge r_{\max} \end{cases} . \quad (15)$$

where

$$R = \begin{cases} \dfrac{r^* - r_{\min}}{r_{\max} - r_{\min}}, \ \ if \ \ r^* < r_{\max} \\ 1, \qquad if \ \ r^* \ge r_{\max} \end{cases} . \quad (16)$$

$$\alpha = \begin{cases} 0, \ \ if \ \ \ r^* < r_{\min} \\ \dfrac{r^* - r_{\min}}{\tilde{r} - r_{\min}}, \ \ if \ \ \ r_{\min} \le r^* < \tilde{r} \\ 1, \qquad if \ \ r^* = \tilde{r} \\ \dfrac{r_{\max} - r^*}{r_{\max} - \tilde{r}}, \ \ if \ \ \tilde{r} < r^* < r_{\max} \\ 0, \qquad if \ \ r^* \ge r_{\max} \end{cases} . \quad (17)$$

Risk degree β accepts values from 0 to 1. Each investor, can define a piece of unacceptable values of risk, and also himself to execute the description of corresponding indistinct subsets, having set five membership functions $\mu^*(\beta)$.

Management model of a portfolio profitableness

To define structure of a portfolio which will provide the maximum profitableness at the set risk level, it is required to solve the following problem [1-4]:

$$\{x_{opt}\} = \{x\} \mid r \to \max, \quad \beta = const \quad , \tag{18}$$

where r и β are defined from (15)-(17), vector's components x satisfy (10).

It is easy to see that (17) can be defined as follows

$$\alpha_1 = \begin{cases} 0, & if \quad r^* < r_{\min} \\ \dfrac{r^* - r_{\min}}{\tilde{r} - r_{\min}}, & if \quad r_{\min} \le r^* < \tilde{r} \\ \dfrac{r_{\max} - r^*}{r_{\max} - \tilde{r}}, & if \quad \tilde{r} \le r^* < r_{\max} \\ 0, & if \quad r^* \ge r_{\max} \end{cases} . \tag{19}$$

Having recollected also, that profitableness of a portfolio is:

$$r = (r_{\min} = \sum_{i=1}^{N} x_i r_{1i};\ \tilde{r} = \sum_{i=1}^{N} x_i \tilde{r}_i;\ r_{\min} = \sum x_i r_{2i}) \quad ,$$

where $(r_{1i}, \overline{r_i}, r_{2i})$ – profitableness of i th security, we receive the following problem of optimisation (20)-(22):

$$\tilde{r} = \sum_{i=1}^{N} x_i \tilde{r}_i \to \max \quad , \tag{20}$$

$$\beta = const \quad , \tag{21}$$

$$\sum_{i=1}^{N} x_i = 1 \quad , \quad x_i \ge 0 \quad , \quad i = \overline{1, N} \tag{22}$$

At a risk level variation β 3 cases are possible. We will consider in detail each of them.

1. $\beta = 0$

From (15) it is visible, that this case is possible when $r^* < \sum_{i=1}^{N} x_i r_{i1}$.

We receive the following problem of linear programming (23)-(25):

$$\tilde{r} = \sum_{i=1}^{N} x_i \tilde{r}_i \to \max \quad , \tag{23}$$

$$\sum_{i=1}^{N} x_i r_{i1} > r^* \quad , \tag{24}$$

$$\sum_{i=1}^{N} x_i = 1 \quad x_i \ge 0 \quad i = \overline{1, N} \quad . \tag{25}$$

Found result of the problem decision (23)-(25) vector $x = \{x_i\} \quad i = \overline{1, N}$ is a required structure of an optimum portfolio for the given risk level.

2. $\beta = 1$

From (15) follows, that this case is possible when $r^* \geq \sum_{i=1}^{N} x_i r_{i2}$.

We receive the following problem of linear programming:

$$\tilde{r} = \sum_{i=1}^{N} x_i \tilde{r}_i \to \max \quad , \tag{26}$$

$$\sum_{i=1}^{N} x_i r_{i2} \leq r^* \quad , \tag{27}$$

$$\sum_{i=1}^{N} x_i = 1 \quad x_i \geq 0 \quad i = \overline{1, N} \, . \tag{28}$$

Found result of the problem decision (26)-(28) vector $x = \{x_i\} \quad i = \overline{1, N}$ is a required structure of an optimum portfolio for the given risk level.

3. $0 < \beta < 1$

From (15) it is visible, that this case is possible when $\sum_{i=1}^{N} x_i r_{i1} \leq r^* \leq \sum_{i=1}^{N} x_i \tilde{r}_i$, or when $\sum_{i=1}^{N} x_i \tilde{r}_i \leq r^* \leq \sum_{i=1}^{N} x_i r_{i2}$.

a) Let $\sum_{i=1}^{N} x_i r_{i1} \leq r^* \leq \sum_{i=1}^{N} x_i \tilde{r}_i$. Then using (15) - (17) problem (20) - (22) is reduced to the following problem of nonlinear programming:

$$\tilde{r} = \sum_{i=1}^{N} x_i \tilde{r}_i \to \max \quad , \tag{29}$$

$$\frac{1}{\sum_{i=1}^{N} x_i r_{i2} - \sum_{i=1}^{N} x_i r_{i1}} \left(\left(r^* - \sum_{i=1}^{N} x_i r_{i1} \right) + \left(\sum_{i=1}^{N} x_i \tilde{r}_i - r^* \right) \cdot \ln \left(\frac{\sum_{i=1}^{N} x_i \tilde{r}_i - r^*}{\sum_{i=1}^{N} x_i \tilde{r}_i - \sum_{i=1}^{N} x_i r_{i1}} \right) \right) = \beta \quad , \tag{30}$$

$$\sum_{i=1}^{N} x_i r_{i1} \leq r^* \quad , \tag{31}$$

$$\sum_{i=1}^{N} x_i \tilde{r}_i > r^* \quad , \tag{32}$$

$$\sum_{i=1}^{N} x_i = 1 \quad x_i \geq 0 \quad i = \overline{1, N} \, . \tag{33}$$

b) Let $\sum_{i=1}^{N} x_i \tilde{r}_i \leq r^* \leq \sum_{i=1}^{N} x_i r_{i2}$. Then the problem (20) - (22) is reduced to the following problem of nonlinear programming:

$$\tilde{r} = \sum_{i=1}^{N} x_i \tilde{r}_i \to \max \quad , \tag{34}$$

$$\frac{1}{\sum_{i=1}^{N} x_i r_{i2} - \sum_{i=1}^{N} x_i r_{i1}} \left(\left(r^* - \sum_{i=1}^{N} x_i r_{i1} \right) - \left(r^* - \sum_{i=1}^{N} x_i \tilde{r}_i \right) \cdot \ln \left(\frac{r^* - \sum_{i=1}^{N} x_i \tilde{r}_i}{\sum_{i=1}^{N} x_i r_{i2} - \sum_{i=1}^{N} x_i r_{i1}} \right) \right) = \beta \quad (35)$$

,

$$\sum_{i=1}^{N} x_i r_{i2} > r^* \quad (36)$$

,

$$\sum_{i=1}^{N} x_i \tilde{r}_i \le r^* \quad (37)$$

,

$$\sum_{i=1}^{N} x_i = 1 \quad x_i \ge 0 \quad i = \overline{1, N} \quad (38)$$

.

The R-algorithm of minimisation of not differentiated functions is applied to the decision of problems (29) - (33) and (34) - (38) [11]. Let both problems: (29) - (33) and (34) - (38) soluable. Then to the structure of a required optimum portfolio will correspond a vector – $x = \{x_i\}\ i = \overline{1, N}$ the decision of that problems (29) - (33), (34) - (38)) the criterion function value of which will be more.

The analysis and comparison of the results received by Markovitz models and fuzzy-sets model

Let"s consider the share portfolio consisting of 5 components.

The portfolio which provide the maximum profitableness at the risk level 0,05 set by the user, includes only two companies shares: MosEnergo (48,5 %) and Tatnft (51,5 %).

Having set various restriction levels on σ (portfolio risk), we receive effective border portfolio set – dependence of the maximum profitableness on risk kind of $r_{max} = r_{max}(\sigma)$.

Under the program we will construct effective border by points of the user, or by 10 automatically generated points.

For the comparative analysis of investigated methods of a share portfolio optimisation real data on share prices of the companies RAO» EES (EERS2) and Gazprom (GASP), were taken from February, 2000 till May, 2006 [10.

In Markovitz model expected profitableness of the share is calculated as a mean $m = M\{r\}$ and risk of an asset is considered as a dispersion of the expected profitableness value $\sigma^2 = M\left[(m - r)^2\right]$ i.e. level of variability of expected incomes.

In the fuzzy-sets model proceeding from a situation at the share market:

- shares profitability of EERS2 is in a settlement corridor [-1.0: 3.9], the most expected value of profitableness is 2,1 %
- shares profitability of GASP is in a settlement corridor [-4.1: 5.7], the most expected value of profitableness of 4,8 %

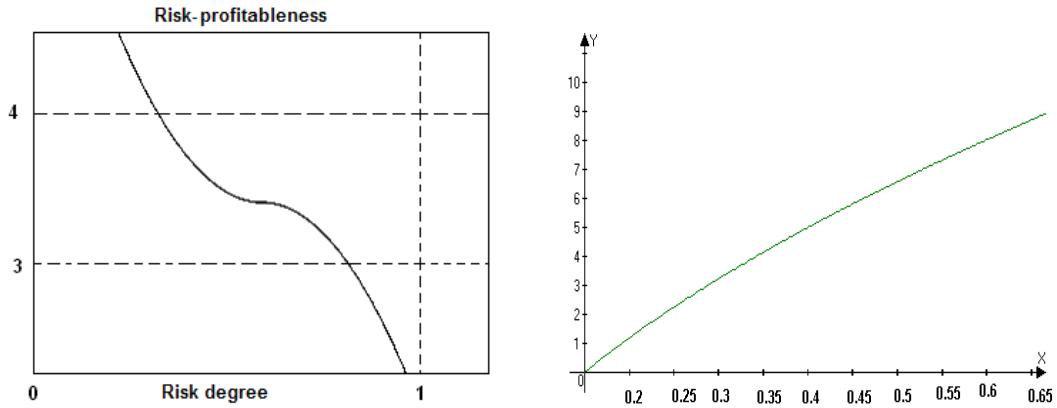
Let critical profitableness of a portfolio is 3,5 % i.e. portfolio investments which are bringing the income below 3.5 %, are considered as the inefficient.

Expected profitableness of the optimum portfolios received by means of Markovitz model, is higher, than profitableness of optimum portfolios, received by means of fuzzy-set model because in Markovitz model the calculation of expected share profitableness is based on indicators for the last periods and the situation in the share market at the moment of decision-making by the investor is not considered. As profitableness of shares EERS2 and GASP till July, 2006 was much more higher than at the present, Markovitz model gives unfairly high estimation.

In the fuzzy-set model profitableness of each asset is a fuzzy number. Its expected value is calculated not from statistical data, but by condition of the market at the moment of decision making by the investor. Thus, in the considered case, expected profitableness of a portfolio is not too high.

The structures of an optimum portfolio which we get as a result of use of both methods, for the same risk levels are quite different too. To find out the reason of this we consider following dependences (fig. 4) [9].

Dependence of expected profitableness from risk degree of the portfolio received



a) by fuzzy-set method. b) by Markovitz model

Fig. 4

Dependences of expected profitableness on degree of risk of the portfolio, received by the specified methods, are practically opposite. The reason of such result is the various understanding of a portfolio risk level.

In the fuzzy-set method the risk is recognised as a situation when expected profitableness of a portfolio drops below the set critical level, with decrease of expected profitableness increases risk of the income from portfolio investments will appear be less than critical value [9].

In Markovitz model the risk is considered as the degree of expected income variability of a portfolio, both in smaller, and in the big party that contradicts common sense. The various understanding of portfolio risk level is also the reason of distinctions of risk degree dependences on a share of this or that share in a portfolio, received by different methods.

In share EERS2, with the growth of low profitable securities in a portfolio, even in spite of the fact that the settlement corridor for EERS2 is narrower, rather than a settlement corridor for GASP, expected profitableness of a portfolio in general falls and the risk of an inefficiency portfolio selection grows.

Level of variability of expected incomes for shares EERS2 proceeding from data 2000-2006 is much lower, than for shares GASP. Therefore in Markovitz model which consider it as risk of portfolio investments, with the increase of ratio of share EERS2 the risk of a portfolio decreases.

From the point of view of the fuzzy-set approach, the more is the ratio of GASP shares in a portfolio, the less is the risk of that efficiency of share investments will appear below the critical level making in our case of 3.5 %.

From the point of view of Markovitz model, average mean deviation from average value for GASP shares is great enough, therefore with growth of their share the risk of a portfolio increases. It leads to that often share of highly profitable assets in the share portfolio received by means of Markovitz model is unfairly small.

According to Markovitz model, thanks to correlation between assets it is possible to receive a portfolio with a risk level less than volatility the least risk security.

In research we consider: having sink 96 % of the capital in EERS2 shares and 4 % in GASP shares, the investor receives portfolios with expected profitableness of 2.4 % and degree of risk 0.19. However investments with expected profitableness of 2.4 % in our fuzzy-set model are considered as the inefficient. If to set critical value of expected portfolio profitableness equal to 2.4% the risk of inefficient investments will decrease, too.

Conclusions

In this work the research in the field of portfolio management was carried out. Markovitz model, as one of most widely applied in the given area and rather recently arisen fuzzy-set approach to portfolio optimisation have been considered. As a result of research the mathematical model based on the fuzzy-set approach for a finding of structure of the optimum investment portfolio has been received, devoided of the majority of lacks of classical

probabilistic models. On the basis of the theory of fuzzy sets the algorithm of optimisation of a share portfolio has been developed. Also the software in programming language C ++ has been developed.

In the course of research and the comparative analysis of Markovitz model and fuzzy-set model for finding the optimal share portfolio structure the following has been revealed:

1. Structures of an optimum portfolio and the indicators of its expected profitableness received by means of Markovitz model and fuzzy-set method principally differ.
2. With reduction of volume of initial data sample according to profitability of assets Markovitz model gives more reasonable results. However, sample that is too small should not be used because it cannot fully represent parameters under
3. Because deviation of expected profitability to the upper bound, as also to the lower bound, is considered in Markovitz model as a risk, dependencies of expected profitability on the risk level of portfolio computed using Markovitz model and fuzzy set method are completely opposite.
4. Due to the mentioned earlier reason, often the fraction of profitable assets in portfolio as computed by Markovitz model is unreasonably low.

Thus, lacks of Markovitz model have been visually proved. Especially is not justified the use of Markovitz model to the share markets of such countries as Russia and Ukraine where economy is very unstable.

Differences in profitableness of the optimum portfolios received using triangular, Gaussian and bell-shaped membership function, in the received results are small enough, especially between the models using Gaussian and bell-shaped membership function.

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ANALYSIS OF SPATIAL-TEMPORAL DYNAMICS IN THE SYSTEM OF ECONOMIC SECURITY OF DIFFERENT SUBJECTS OF ECONOMIC MANAGEMENT

Alexander Kuzemin, Vyacheslav Lyashenko

Abstract: The importance to solve the problem of spatial-temporal dynamics analysis in the system of economic security of different subjects of economic management is substantiated. Various methods and approaches for carrying out analysis of spatial-temporal dynamics in the system of economic security are considered. The basis of the generalized analysis of spatial-temporal dynamics in economic systems is offered.

Keywords: data interpretation, regression analysis, economic dynamics, mathematical model, economic security.

Introduction

Development of various subjects of management (beginning with separate enterprises and ending with regions, the country as a whole) is objectively interdependent with variations taking place in the exterior medium where such processes function. In this case fleetness of economic processes, which in separate cases vergers on unpredictability and errors in forecasts in reference to the following economic development, prevailing of globalization tendencies and the necessity to prevent economic crisis and decays motivate the importance of considering the problems concerning economic security of such objects.

At the same time the problem of agreeing various characteristics and indices of economic management functioning processes becomes rather urgent for making adequate decision in the system of their economic security, this determines the necessity of considering, first of all, such statistical data which describe their spatial-temporal dynamics.

Substantiation of the aim and problems of the investigation. Complexity of different problems solution in the frameworks of the chosen investigation direction is associated with the necessity to process rather great body of statistical information which as a whole can be presented in the form multidimensional matrix structures. In this case traditionally the problems of the indicated line of investigation are solved in the context of the definite problems of the specific subject of economic management taking into account the economic situation development temporal factor being an important component when building up any economic security system. So one of the abundant tools for solving the economic security analysis problem is application of methods and approaches of the simulation modeling [1], this makes it possible to link them with visualization and significance interpretation of movement of the data being studied. In this case recognizing that specific characteristics of the analysis of activity of economic management subjects are interconnected, as a rule, with the temporal factor, the use of the apparatus of the temporal series analysis and prediction theory [2, 3] is of no small importance. Nevertheless, both in the first and in the second cases, as a rule, the problem of the obtained data agreement remains beyond field of vision in the course of analysis of available statistical data which reflect dynamics of different components of economic activity for making adequate decisions.

An economic managing subject faces constantly with the problem of making an acceptable decision in the process of functioning; this eventually defines the importance of analysis of the spatial-temporal dynamics when creating a corresponding economic security system. Directly the given conclusion emerges from the fact that a definite economic managing subject progresses through widening living resource space, based on resolving contradictions between external and internal environment which are an integral component in any decision making and require a definite coordination.

Moreover, one should take into account that decision being made must be weighted and substantiated on the basis of statistically significant conclusions which make it possible to reveal, first of all, available tendencies of economic development. Consequently, rather complicated problem emerges interdependent both on justification and building of an adequate model explaining interconnection between the data being studied, and the following analysis using the built model of the available set of the statistical data. In the general terms the adequacy of the corresponding analysis model should be consistent with the problem of interconnection dynamics analysis of some economic process (or phenomenon) being investigated between different subjects of the market in the

definite temporal interval. Solution of the given problem, on the one hand, encounters insufficient quantity economic process (or phenomenon) being investigated and on the other hand it encounters the necessity to process a set of data of different dimensionality. Specificity of the statistical data describing some object being investigated leaves a definite imprint on the formulated problem solution. That is why the problem of agreement of various characteristics and indices of economic managing subjects functioning processes for making adequate decisions in the system of their economic security is so significant.

Thus, as the prime objective of the investigation one should set off, first of all, examination of the available approaches to the investigation of the spatial-temporal dynamics of different economic managing subjects. At the same time the problem of such approaches critical analysis performance with revealing features of the corresponding analysis together with the problem of consideration of the feasible generalization in the spatial-temporal dynamics analysis of different economic managing subjects are important.

Spatial-temporal dynamics in the system of economic security and methods of its analysis. The most simple and abundant example of the spatial-temporal dynamics in the economic systems may be considered a set of the data characterizing development of some process (phenomenon) in time having regard to variety of available economic managing subjects. By description of such processes (phenomena), in particular, is meant dynamics of different indices of the socioeconomic development of the country in connection of its separate regions or development of some sector of the economy taking into account functioning of its separate economic components. Dynamics of the banking sector of economy development both taking into account regional features of separate administrative territorial units of the country and presence of a definite number of economic managing subjects defining the corresponding activity in this or that region can exemplify such a description. The analysis of the priorities justification, while choosing some variety of stocks based on some set of stock exchange indices dynamics investigation, should be indicated as an example of more complicated example of the spatial-temporal dynamics. Complex description of some economic managing subject behavior with regard to plurality both of indices of such description, the presence of a definite system of limitations on the system of such indices and consideration of the temporal factor of the analyzed indices factor system is rather sophisticated spatial-temporal dynamics process.

At the same time, as a rule, the spatial-temporal dynamics analysis in the economic systems amounts either to the cross-section regression, or to the temporal series regression [4]. The first type of regression makes it possible to estimate the interconnection between different data being analyzed at a definite moment of time; the second type is the interconnection between the data of one (or several) parameter during some interval of time. In this case application of the first type of regression, as a rule, doesn't take into account the dynamics of data being analyzed, application of the second type of regression doesn't take into account the presence of interdependent influence between the studied parameters with respect to different economic managing subjects. In the total the generalized model of analysis can assume the structured form:

$$Y = F(X_1, X_2, ..., X_n) \Leftrightarrow \begin{cases} y^1 = f^1(X_1), \\ y^2 = f^1(X_2), \\ \quad ... \\ y^n = f^n(X_n), \end{cases} \tag{1}$$

or

$$Y = F(X_1, X_2, ..., X_n) \Leftrightarrow \begin{cases} y^1 = f^1(x_1^1, x_2^1, ..., x_n^1), \\ y^2 = f^2(x_1^2, x_2^2, ..., x_n^2), \\ \quad ... \\ y^i = f^i(x_1^i, x_2^i, ..., x_n^i), \end{cases} \tag{2}$$

where

Y – dependent variable characterizing some generalized its value;

$\{X_n\}$ – set of independent variables characterizing some generalized their values;

$F(...)$ – function representing the kind of regression dependence between the generalized values of variables being investigated;

y^n and y^i – dependent variables with regard to the analysis of the action of one independent variable X_n on the whole interval of time being investigated or taking into account analysis of the action of all independent variables $\{x_n^i\}$ for some definite interval of time;

$f^n(...)$ and $f^i(...)$ – function representing the kind of regression dependence between the dependent and independent variables represented with non-generalized values.

Variation of interconnection in the growth of general bank segment assets of the international bond market can serve as a concrete example of such spatial-temporal dynamics analysis. This is related to that in the given case the accounting of temporal unevenness of bank segment assets of the international bond market growth is obligatory. As a result the given feature can be represented through adequacy of the corresponding regression dependence equation for a longer period of time to the regression equations system defining the time interval being investigated in shorter intervals:

$$A_y = 0{,}697 * VB_y + 0{,}357 * NF_y \Leftrightarrow \begin{cases} A_{Q1} = 0{,}664 * VB_{Q1} + 0{,}346 * NF_{Q1} \\ A_{Q2} = 0{,}782 * VB_{Q2} + 0{,}245 * NF_{Q2} \\ A_{Q3} = 0{,}672 * VB_{Q3} + 0{,}399 * NF_{Q3} \\ A_{Q4} = 0{,}476 * VB_{Q4} + 0{,}660 * NF_{Q4} \end{cases}, \quad (3)$$

where

A_y – variations in general bank segment assets of the international bond market in annual estimation during 2000–2006,

VB_y – variations in requirements on banks in annual estimation during 2000–2006,

NF_y – variations in requirements on non-banking sector in annual estimation during 2000–2006,

$A_{Q1}, A_{Q2}, A_{Q3}, A_{Q4}$ – variations in general bank segment assets of the international bond market in quarterly estimation during 2000–2006,

$VB_{Q1}, VB_{Q2}, VB_{Q3}, VB_{Q4}$ – variations in requirements on banks in quarterly estimation during 2000–2006,

$NF_{Q1}, NF_{Q2}, NF_{Q3}, NF_{Q4}$ – variations in requirements on non-banking sector in quarterly estimation during 2000–2006.

Such a representation of spatial-temporal dynamics in the form of the regression dependence makes it possible to present the interconnections existing between the data being analyzed in the combined-structured form and to investigate them in greater detail. Nevertheless, the given approach doesn't explain in full measure the degrees of the interaction between different economic entities.

The following approach used for analysis of spatial-temporal dynamics in the economic systems can be introduction of the coefficients leveling asymmetry of the information influence between the variables been analyzed into the regression equation [5, 6]; this, as a result, makes it possible to eliminate the action of the variety being investigated both of the economic entities and separate features of their territorial distribution. The disadvantage of such approach one may consider the lack of a unified methodological base for such coefficients construction, this hampers the analysis unified method construction. Moreover, the given approach is unlikely to be applied to the information asymmetry elimination when solving the problems of securities version choice for investment on the basis of the stock exchange index analysis. This is associated with that in the given case one should, first of all, pay attention to the complexity of carrying out the corresponding analysis owing to the uncertainty of the stock exchange indices dynamics of developing countries [7].Consequently, to solve such a problem associated, first of all, with attainment of sufficiently stable and high profit on financial investments one should use the fuzzy set theory approaches having considered fuzzy intersection operations for membership functions by every of the stock exchange index being investigated [8].

The concept of the main components method [9] should be indicated as one more approach making it possible to analyze of spatial-temporal analysis dynamics in the economic systems. The essence of such a concept for the spatial-temporal dynamics analysis can be reduced to the definition of the most significant action of one or other economic entity whose data are used for further investigations. But in such an event, as in the case of the regression equations structured system building, possible interaction between different economic entities is not taken into account.

The question of estimating the mutual influence of the financial flow on the part of different economic agents on the activity of each other is no less important in the context of the considered problems [7]. One of the approaches making it possible to give an answer to this question consists in the mutual analysis of the corresponding temporal series of such flows. Then, if there is a mutual subordination between two series (stability of correlation interconnection taking into account a definite lag and group of series transform being its manifestation) one should say about mutual action of one series on another one. Here two cases are possible:

- economy entity with a dominating series acts negatively on the financial flows movement of the other economy entity with a co-subordinated series if there is a stable correlation interconnection on the positive lags of the series being investigated;
- economy entity with a dominating series acts positively on the financial flows movement of the other economy entity with a co-subordinated series if there is a stable correlation interconnection on the negative lags of the series.

At the same time, when investigating the mutual dynamics of development of such economy entities, it is expedient to use the "fuzzy set levels" concept making it possible to build adequate procedures of mutual analysis of such economy entities spatial-temporal dynamics [10].

Basis of the generalized analysis of spatial-temporal dynamics based on applied registration analysis. Considering foundations of the regression models feasibility for spatial-temporal dynamics analysis it should be noted, first of all, that it is expedient to consider just the regression equation set as the description model of spatial-temporal dynamics of some economic process (phenomenon). In this case transition to such a description comprises the regression equations system built on the standardized transformation scales in the variables space. This is associated with that the regression parameters estimates turn out to be measured in the units of the variables mean square deviation from their mean values and they become comparable to themselves and other regressions parameters. Thus, considering some system of such equations for different sets of data Y^* and X^*, describing dynamics of functioning of some definite number of economic entities (k), it is possible to speak about that it is completely described with a set of the standardized coefficients $\{\eta_k\}$ representing correlation interconnection between dependent and independent variables of the economic entities under investigation.

Then in three-dimensional space the graphical interpretation of the regression equations described with the standardized coefficients (Fig.1) can be presented as a projection on the plane $Y^{**}\eta^X$ of the cone which represents the essence of the spatial-temporal interconnection of the parameters being analyzed; in the simplest case one should single out among them the following:

- the variable being investigated represented with its weighted-mean values Y^{**};
- the standardized coefficients of the interconnection regression of variables represented in the three-dimensional space in the form of their generalized weighted-mean values of the variable not represented by η^X;

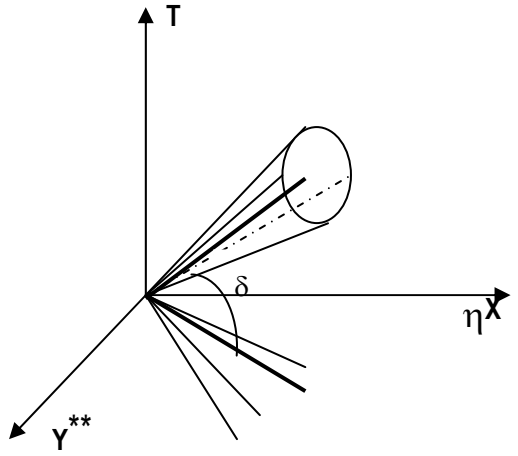

Fig.1. Three-dimensional graphical representation of the spatial-temporal dynamics analysis generalized characteristics

- the time factor T. In this case the generators of the considered cone (Fig.1) represent the investigated parameters interconnection dynamics by every of the economic entity being analyzed.

Thus, the regression coefficient δ value may represent the spatial-temporal dynamics generalized characteristics of the process (phenomenon) being analyzed among weighted-mean values of the value chosen for further investigation and standardized regression coefficients among the main investigated variables in their mutual temporal dynamics:

$$Y^{**}(T) = \delta \cdot \eta^{X}(T). \quad (4)$$

It is possible to interpret such coefficient δ as the angle of slope of the cone, representing the interconnection essence of the spatial-temporal dynamics analyzed parameters of the economic process (phenomenon) being investigated, to the plane $Y^{**}\eta^{X}$. From economic standpoint such an interpretation can denote the quality of development (functioning) of the process (phenomenon) being investigated. As this takes place, insignificant value of such coefficient is indicative of non-uniqueness and insufficiency of the process (phenomenon) being investigated, while its significant value, that corresponds to remoteness of the cone from tqhe plane $Y^{**}\eta^{X}$, is indicative of dynamic development of the considered process (phenomenon). Then the essence of the spatial-temporal dynamics analysis of the process (phenomenon) being investigated in the system of economic security of different economic entities reduces to:

- first, to the control of the considered regression coefficient in the equation 4;
- second, to the prevention of the possible values leaving the definite limits defining efficiency of the security system control over some economic entity.

Conclusions

Thus, interconnection between spatial-temporal dynamics analysis of the process (phenomenon) of some economic entity and efficiency of security system management is considered in this work. The given interconnection is based on consideration of the spatial-temporal dynamics generalized characteristics basis which makes it possible to introduce the generalized management efficiency characteristics of the corresponding security system into consideration. While more detailed formalization of such characteristics is the subject of further investigations.

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THE PROBLEMS OF FORMING THE INNER PERSONAL CONFLICT AS A FACTOR WHICH INFLUENCES DECISION-MAKING

Helen Shynkarenko

Abstract: the article views examine the problems concerning with the sources of origin of unconscious the inner personal conflicts and the way the presence of this factor is reflected on the decision-making process by a person.

Keywords: conscious, unconscious, super conscious, inner personal conflict, complexes, self-abasement complex, decision-making.

Introduction

We can observe the constant forming of new directions, uniting different areas of scientific knowledge in our modern world. Researches who relate to the problem of decision-making belong to such directions. Decision-making is a central aspect on all levels of information organization by any person, body of men, systems as "person – machine". This complicated complex problem includes different aspects: somatic, psychological, cybernetic et al. Psychological aspects of the problem are bound up not only with role analysis but also deal with an unconscious sphere of a person.

This work examines some problems, concerning the source of origin of unconscious the inner personal conflicts and the way the presence of this factor is reflected on the decision-making process by a person.

Decision-making as a process of personality stereotypes reorganization

The most difficult, both conscious and unconscious inner personal decisions – are those which are accepted for in the conditions of time deficiency, on the one hand, and on the other hand – in the conditions of informational vagueness and antipathy, related both to external (social) and by internal (personal) factors. These decisions serve as the main criterion for person maturity, his/her willingness to account for his/her decision-making. We can relieve the difficulty of decision-making only in case if they (decisions) are made beforehand, but all of us know that during the process of vital functions it is not always possible. To make a decision means to "take away" the antagonisms of "matured" problem with which personality renounces to put up with in future. A necessity in its making arises when stereotyped, usual reaction on obtained information is impossible and a personality have to operate in a new fashion.

But such kind of alteration is a difficult nervous work, and sometimes, a real challenge for a man. Regularity of higher nervous activity knowledge discovered by I. P. Pavlov helps us to understand the cause of these difficulties. It is well known, there is a continuous systematized division of the irritable and brake states in the cerebral [brain] cortex which in conditions of reiterating circumstances are immobilized easier and more automated. That is why a dynamic stereotype appears. And its realization needs lesser consumption of nervous work. Sometimes it is very difficult to change set stereotype and to result in conformity with new circumstances, new requirements of life. Fixing certain experience and saving long time, dynamic stereotypes are inclined to strong retention. Formed in the process of everyday organism balancing with an environment, vital stereotypes make the basis of human personality, usually stable enough in a form and dynamic in maintenance.

If a dynamic stereotype is well immobilized, it is a sufficient conservative system. That is why its withdrawal and making new one is a difficult task for the nervous system, which may result in temporal disorder of higher nervous activity. Only a strong nervous fellow can pass such muster. And only such personality can cope with his own complexes, i.e. the group of correlated conscious and unconscious ideas and feelings which have a dynamic influence on person's behavior.

Complexes as a component of an unconscious psyche sphere

To understand the essence of complexes clearer, their influence on human activity, it is necessary to understand the comprehension of unconscious, conscious and superconscious, and also their roles in the personality psyche.

The offered model of personality, accepted in a psycho-analysis, is the co-operation of three levels, which are in the ratio. It is “It” (Id), i.e., a deep level of the unconscious drives, original reservoir of unconscious irrational psychical reactions and impulses, which are biological inherently. It is a basis of person activity, that psychical instance which governed by its law. «It» is a unique psychical energy source and follows only the principle of pleasure. Instincts belong to the unconscious sphere (food, sexual, self-defense and other), which cause unconscious desire, emotion, drive and later can get into the area of consciousness of a personality.

Consciousness (conscious – «Ego») unlike unconscious allows a man to accomplish higher control of his\her psychical processes and behavior, to direct the course of his/her psychical and evident activity to a proper direction and also to analyze his/her consciousness. It includes person attitude both to himself and to other people, in other words appears as consciousness.

And finally, “Super-Ego” is the inner personal conscience, i.e., the instance, which personity values and purposes of society.

A person realizes moderate part of psychical activity, other part remains unrealized. But the verge between conscious and unconscious is mobile. And with time a person can interpret his/her emotions and intuitive suppositions logically. Also he/she can understand the reasons of his/her rash doings. On the contrary, with automatism forming we can see their transition to the sphere of unconscious. Thus, in the case of unconscious acts of behavior a person gets necessary information from the outer world, but this information does not become aware, but it is processed and used at most different levels of the central nervous system.

The unconscious adding leads to loosing the work on consciousness and increasing person possibilities in scientific or artistic creation. We can observe it through reflexes, instincts, usual automated actions and norms (as far as a person masters them their realization go down). There are some things, the causes of which are not realized. These are: aspirations, feeling and doings; erroneous actions, expressive behavior, free associations, dreams, neurological sign reactions and fit of passion complexes.

According to Z. Freud, such manifestations are able to cause a permanent conflict between the levels of personality in one’s mind, (“Super-Ego”, “Ego”, “Id”). That is why, to make the extenuation of tension and guilt, caused by such a conflict, a psyche created some protective mechanisms, called for “restrain, force out” unpleasant or forbidden ideas, desires, feelings, doings. Their removal is an autonomous procedure because this complex is unconscious. When it activates every person acts too emotional, a decision-making is influenced by unconscious person, because we react to not a relevant situation, but to all similar situations.

	Protective psychological mechanisms on the theory of psycho-analysis
Rationalization	pseudo-clever explanations of one’s desires and doings, which in reality were caused by some reasons confession of which would threaten the loss of self-esteem
Ousting	avoidance of internal conflict dint of “cutting” the unacceptable reason or information from the consciousness
Forgetting	special case of displacement, which is concerned with forgetting of unpleasant information and intentions
Transfer	action substitution with the unavailable object for the actions with accessible one
Projection	unconscious ascription of your own feelings, desires, drawings to the other person, understanding their social inadmissibility
Regression	returning to the earlier developmental stage or to more primitive forms of conduct and thought
Substitution	protective mechanism, concerning with the action transferring from an inaccessible object to an accessible one
Denial	the process of elimination and ignoring of traumatizing perceptions of the external reality
Isolation/ estrangement	isolation and localization of the factors which traumatize a person in the consciousness

Information about bad or disgraceful acts of a person, “forbidden” desires and his/her traumatic emotional experience can be displaced to the unconscious region of psyche, and as a result unconscious complexes appear. These complexes are able to influence consciousness of a man, his emotional state and behavior. Also negative changes in physical and mental health of a person may appear.

That is why some personalities can’t ground their doings logically because of their own complexes influence them greatly (people with complexes). In such a condition as this we can’t talk about making adequate decisions by a person.

At first it appears in unconscious man in the embryonic form. Outwardly it results by way of whims, increased irritability, thoughtless acts, etc. In future, these complexes develop and involve a great region of psyche. This leads to the appearance of such serious states as: pathology of personality, neurosis, psychosomatic and mental diseases.

We can’t see these psychical formations because they are invisible but experienced by emotions. Visually such complexes appear in the stereotyped patterns of behavior and formed not only by the strong traumatized emotional experience but also by the insignificant constantly repeated shocks. If the material of unconscious complex is affected at emotional or values levels, then all unconscious intercommunications and provoked by them incongruous behaviour stereotype patterns are activated. Such process is autonomous, because the complex is unconscious. A person reacts too emotional when it activates, decisions are made under the influence of an unconscious person. This happens because we react not to an actual situation, but to all similar situations, which we experienced in our lives, when the complex remained unconscious. Usually such kind of its manifestations ends with the feeling of shame because of we were not able to control a situation. The greater excitation provoked by the complex, the greater emotional complex activity and the lesser freedom has our will.

Self-abasement complex as a source of inner personal conflict

A lot of inner personal conflicts appear because of such psychical activity. And in its part these complexes have a great influence on a person’s decision-making.

Inner personal conflict is a self-contradiction, which personality perceives and emotionally experiences as a meaningful psychological problem which has to be solved and which gives rise to internal consciousness work, but not always directing it to overcoming this contradiction.

So, if we, for example, take a personality with self-abasement complex, then it is quite possible, that in case when self-contradictions appear, a person has a mental stress. And at the same time the adrenalin which comes in blood can cause pleasant (both conscious and unconscious) feelings, which a person will want to reproduce unconsciously. To understand this process better we suggest you to examine it by the example of a personality with self-abasement complex.

Such person has an understate self-appraisal. That is why, estimating himself/herself, he/she considers himself/herself to be the most deteriorative person. But at the same time his/her own needs still exist. Such people just repress and deeply hide their needs. This caused the unconscious inner personal conflict. And it is the reason of life chronically dissatisfaction. But, in spite of the premises, a person with the self-abasement complex takes hard his defect (even the smallest one, which nobody will notice).

It is one of the inner conflict manifestation, since as a matter of fact, such kind of people at all external modesty and demonstrated simplicity have a high level of complaint against what “worthy man” must be. The cause of this complex is the difference between such types as “Ideal I” and by a perception of “Real I”.

For all that a person with self-abasement complex looks modest and ready to please everyone, in fact, is fully concentrated on himself, constantly aching for his doings in people opinion. Such kinds of people always think about what they have done wrong. When such a person works for obliging, first of all he cares for himself. He/she is sure that he/she has to look «good», «nice», and modest, that he/she can’t annoy others and stand out against a background of those around him/her. He/she thinks that it is necessary to be “for all”. He/she always compares himself/herself with other people, but always decides not in his/her favour; also he/she is sure that he/she must be better than other people. Such comparison makes him constantly say “sorry”, because it is easier to let people know beforehand about his/her failure, then to experience their disappointment afterwards. Besides, having let them know beforehand about himself/herself, he/she shows himself/herself as a containing self-criticism, conscientious and modest person; on the other hand, it is not only corroborate him/her his/her concernment but also somehow raises him/her above others (i.e. a compensatory protective mechanism snaps into action).

A person like this extremely depends on other people's opinion that is why any kind of criticism from their side is unbearable for him. And it shows us another contradiction which corroborates the availability of inner personal conflict. While criticizing oneself plainly, he feels not only pain and anger, if somebody agrees with him but also harbors hostile against such people. He criticizes severely oneself not for being agreed with but quite the contrary, because it will give him the opportunity to get the confirmation of his concernment.

Very often such type of a personality bears limitations, watching how other people advance. Proving his insignificance, he sometimes even aims to be proved of his concernment (i.e. to make sure from reverse). He can be very convincing in proving his failure that as a result a lot of people start treating him in accordance with his behavior. And as a result we have a person with such feeling as vindictiveness and hostility. But at the same moment these feelings join such feelings as shame and guilt.

So, the inner conflict of a personality lies in, that in self-abasement person's heart of hearts is almost sure, that he deserves disdain but at the same time he wants to look better than others. Being unable to accept himself such, as he is, he is not able to believe that others, knowing all his failures, can be friendly with him. Such personality stops perceiving any positive feelings of other people. And that person doesn't realize that he has some problems: he is sure that he is fully right, as psychological defense mechanism starts working.

Sometimes such people can live in grinding poverty and destroy oneself by alcohol and drugs. But in a number of cases they can have a normal way of life, work much and even achieve some success. And even so they are afraid of great achievements, because once attained results involve suitable expectations of other people. But namely this scares a person with the self-abasement complex, because he is actually afraid of failure. And it means that he scares to disappoint other people. In future he will more thoroughly decide to have no success because it is very difficult for him to experience fears of the successes and failures. That is why he passes the responsibility of his life to another person, a more "better" one. A strong, active, autocrat partner who is ready to take care of his life and who wants to dictate his will. Just such kind of a person shows the best correlation with the self-abasement person, who is ready to vanish and please, as he got used to obey and be insignificant. Such personality feels absolutely dependent on somebody, but this dependence – is the only possible mode of his existence.

Accordingly, a partner has to have all qualities, allowing him to occupy a dominating position. It is possible to presume that with the help of long relationships with "better" personality and his benevolent attitude and care for the development of his darling, we can even say that the belief in own strength and self-esteem may come to take the self-abasement`s place. But, as a rule, a self-abasement person feels drawn to exactly the dominating people, and those consider him to be a fertile field for satisfaction their needs in the power and control.

The reason for development of such complex may be: steep demands from the direction of parents, on the one hand, and extremely exacting parents are never contented completely by their children doings and actions, on the other hand.

In the first case parents want to stimulate their child to improve him and to achieve success, but instead of their wish get another thing: a child understands that he simply can not satisfy such high requirements. In future he demands similar of himself: he starts comparing himself to other people, constantly criticizes oneself and masters, that if he does nothing, he gets no critical remarks.

In the second case we can see that a child's fear of collapse develop bit by bit. It fetters the child more and more, so it leads to the new failures. But as it is vitally important for him to get love, a kid tries to compensate his awkwardness and unskilfulness that is why he tries to be an affectionate, obedient and unnoticeable child. And if there is something to do for a child, he beforehand apologizes for his inferiority, as if notifying in advance about disappointment (but he is a winner in any case: if he doesn't manage with the task – he has let them know beforehand about that and thanks of the warning he is "above" that people, who are waiting for positive results; if he manages with the task – he is a significant personality, and it is confirmed by those, who encouraged him, although he knows that he is very good in unconscious).

However a low self-importance of a child doesn't mean that he is grotty. Very often self-abasement corrodes the soul of very talented people. Nevertheless a child achieves some success periodically. But every kid's achievement causes only one reaction of his parents: "you see, you may if you want". And now parents expect more from the child. They want him to be blameless and perfect. The "demand slat" rises and the threat of failure increases. So the fear of success develops for a kid. It is better for him to restrain his abilities.

It also happens that one of the parents passes his own self-abasement complex to the child. And it creates the purpose not to show oneself, because a lot of more clever and better people exist.

Thus, personality forming with the self-abasement complex may arise from the influence of such factors:

Paternal demands:	**Child's conclusions**	**Forming personality strain**
A child has to: 1) meet parents' expectations; 2) be better than others; 3) look better than others; 4) learn to do different things earlier than others; 5) do everything perfectly; 6) not "show oneself" If a child doesn't win: 1) he is a nonentity; 2) he upsets his parents; 3) he is unworthy of his parents` love; 4) he is unworthy of respect.	If a child can not manage the parents` task: 1) means that he is an inferior child; 2) they love clever, skilled, successful people; 3) he is unworthy of paternal love. To deserve paternal love, a child has to: 1) try to little annoy his parents lesser; 2) be nice and attentive; 3) try to let them know beforehand about his possible failures not to make them angry; 4) the lesser he does something, the lesser he is crossed with; 5) it is desirable not to initiate and not to work; 6) try not to achieve much success, because it is a matter of luck and later on he will disappoint his parents and they will love him less.	1) egocentrism; 2) diffidence; 3) timidity; 4) high requirements level; 5) aspiration for wining the sympathy of people by dint of pity; 6) permanent feeling of guilt and shame; 7) fear of the failure; 8) fear of the success; 9) touchiness; 10) covert vindictiveness; 11) to be beneath criticism; 12) avoidance of disputed situations even to the prejudice of himself; 13) impossibility to express your opinion, stick up for oneself; 14) chronic life dissatisfaction 15) aspiration for making smb. responsible for your life and for making momentous decision; 16) inclination to choose dominating partners, directing his life; 17) inclination to choose partners who is able to criticize and humble him (the model of paternal family); 18) susceptibility to depression

Permanent suppression of the energy and aspiration for being unnoticeable adversely affects the character of every person bit by bit, and later on determines his future.

There are no tests which can help us reveal people with the self-abasement complex. But if you discovered without any special test such features as: low self-appraisal, timidity, high requirements level, permanent feeling of guilt and shame, touchiness, being beneath criticism, avoidance of disputed situations even to the prejudice of himself, impossibility to express your opinion, stick up for oneself, aspiration for making somebody responsible for your life and for making momentous decision, diffidence, inclination to choose partners who is able to criticize and humble him, aspiration for winning the sympathy of people by dint of pity, susceptibility to depression, etc. you can say with a high probability that it is the personality with the self-abasement complex.

Decision-making problems

In most cases the examined type of personality will make decisions under the influence of unconscious emotions, which impede the constructive activity in this situation. The inner personal conflict is caused by this. And this

conflict “draws” a person into a vicious circle. Inadequacy of the made decision very often causes (both consciously and unconsciously) a person feel shame, and this, in its turn, impede with making adequate decision. That is why, there is high probability that, while making decision, such type of personality will direct the following:

- try to keep in the background, avoiding to have his own opinion;
- avoid to make decision independently at all;
- undertake something important without authoritative outsider prompting;
- try to make someone else (who is as he/she thinks more competent) responsible for solving the problems;
- in case of inevitability of decision-making he will apologize beforehand for his incompetence, incomprehension of what is going on, unskilfulness, etc.

Thus, according to Thomas-Kalmias` net, in case of conflict situation this type of personality will try to escape and/or adopt himself. He/she will do this because such type considers it to be the best acceptable way for himself/herself. Besides, such people beforehand sure not only in the frustration of their own plans but also often beware of giving optimistic prognosis concerning either, one or another projects, if they are included in it.

Conclusion

Undoubtedly, any typology is approximate and relative. It is pretty rarely possible to meet people, exactly reflecting any described type. But psychological portraits help us to find bearings in the inner world of a person better, also it helps us to see the hidden “links” quicker, make assumptions and check them up.

For example, clashing with such kind of people in our everyday life we will be able not only understand what affects decision-making in a psyche of such a person, but also predicts him beforehand. That is why, it is very important to take into account psychological factors, which influenced subjectivity of evaluation of personality either, one or another phenomenon, while appointing experts.

But if a person wants to change himself, his type of personality, then, as a result of solving his self-contradiction, originating from the influence of various complexes, he/she can get (first of all – through adequate self-appraisal forming) the new vital functions. And on conditions that previous obstacle negotiation of inner personal development, a person has the opportunity to turn them into personal inner experience which will help him to build the constructive scenario of his life.

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A SMALL SETTINGS CASE STUDY USING TSPI IN A SOFTWARE PROJECT

Jose Calvo-Manzano, Gonzalo Cuevas, Tomás San Feliu, Edgar Caballero

Abstract: This article introduces a small setting case study about the benefits of using TSPi in a software project. An adapted process from the current process based on the TSPi was defined. The pilot project had schedule and budget constraints. The process began by gathering historical data from previous projects in order to get a measurement repository. The project was launched with the following goals: increase the productivity, reduce the test time and improve the product quality. Finally, the results were analysed and the goals were verified.

Keywords: TSPi, Small Settings, Process improvement.

ACM Classification Keywords: D.2.9 Software Engineering – Management, software process models

Introduction

Large and small and medium enterprises have common problems related to the management and quality [IPRC, 2006] of software projects. This generates costs overruns, low quality and cancelled projects [Standish Group, 2004].

Some processes models like the CMMI are successful enough, but they are not affordable for the small organizations [IPRC, 2006].

Organizations have recognized that the control of their software processes affects the success of their projects, *"they know what to do but not how to apply it"* [Noopur, 2003].

A new research line based on the process improvement in small settings is arising in order to facilitate competitive capabilities for this environment in a global market [Glazer, 2006]. Small Settings include small and medium organizations, and small software projects [Garcia 2006].

Garcia [Garcia, 2005] and Serrano [Serrano, 2006] show how to get CMMI maturity levels using TSP in Small Settings. Some CMMI level 5 organizations have improved their quality levels using TSP [Noopur, 2003].

Team Software Process (TSP) is a framework that provides a customizable process based in an excellent experience in planning and managing software projects [Humphrey, 2006]. It guides teams in managing cost, schedule and quality [Noopur, 2003].

This article shows through a case study the results of using an adapted process based on the introduction of the Team Software Process (TSPi) in a small organization.

The following goals have been established for the adapted process:

1. To finish the project within the established schedule, cost and effort.
2. To reduce the test time.
3. To increase the productivity and improve the product quality.

The organization decided to use TSPi in order to accomplish the previous goals assuming the risk of modifying its previous processes. Besides, there was not enough time or resources to elaborate a complete training in TSPi and PSP.

Therefore, the organization decided to apply the basic TSPi principles, getting a customized process as a result of combining TSPi with the previous organizational process.

A basic training was provided for the new process, and historical data were collected in order to facilitate the estimation of the pilot project and the comparative study.

In the following section, the article shows the organization, the development context and the pilot project attributes. Later, the historical data collection will be described, and the new process will be showed and the advantages pointed out. The project goals will be verified using the project measures, and finally, the conclusions will be showed.

The schema showed in Figure 1 resumes the factors considered in the project.

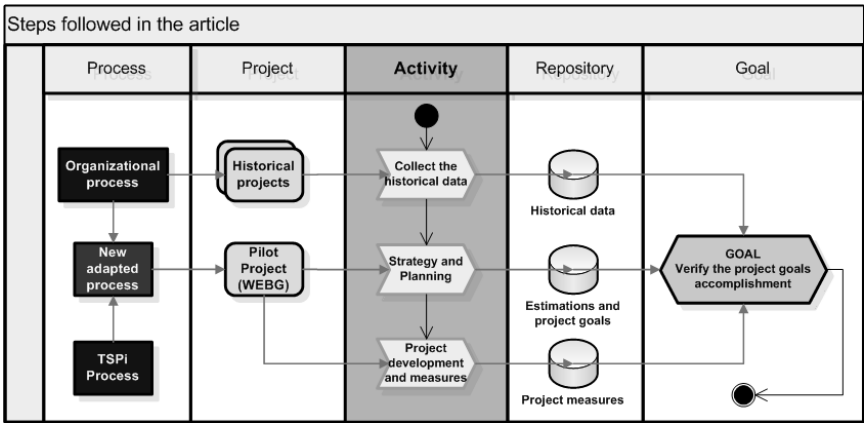

Figure 1 – Factors considered in the project

Context: The organization and the pilot project

UPTA is a Spanish intersectorial organization who takes care of all the scopes of economic activity which they are exerted by self – employment. UPTA leads a lot of projects which generally need a specific software development and in the last year, the number of software projects has increased.

The working scenario has changed to a new environment where many projects were developed simultaneously, and with a greater number of involved people. As a result of an internal assessment, senior management detected that projects were delayed, dedicating additional efforts to accomplish the objectives. Moreover, products quality had decreased.

UPTA was interested in introducing a process model such as CMMI, but it could not afford it.

Besides this handicap, UPTA had a project (called PRO) with schedule and budget constraints, and was delayed. The organization selected this project as the pilot. The purpose of "PRO" was to develop a tool that allows creation of a web site based on templates and a basic content system where the end users does not need technical knowledge.

According to TSPi criteria, during the strategy phase, the team agreed to reduce the initial functionality by 20%. The team established the following project goals (see Table 1):

Table 1 – Project goals

Measure	Goal
Schedule deviation	< 8% (1 week)
Effort deviation	< 15%
Budget deviation	< 15%
Test productivity	< 33.4 hours/KLOC (historical average)
Project productivity	> 7.3 LOC/hour (historical average)
% Release defects	< 5%

Collecting the historical data

Data on previous UPTA projects were not enough. There were only schedule and budget data, but in order to verify the project goals, defects and phases efforts data were needed.

Estimations values and measures related to schedule, size, effort and defects were collected. In addition, some derived metrics were calculated in order to analyze the project results.

Lines of code (LOC) were chosen because it could be done automatically. Based on the LOC and the effort of previous projects, the historical average productivity was calculated. This information was used to estimate the pilot project size.

In order to support the analysis, historical projects were divided into three phases:

- Development phase (process): From the launch until before the test.

- Test phase: It includes integration and system tests.
- Release phase: From the product release to the customer until the end of the third month of use.

Phase effort and defects data of these phases are approximate values because there was no previous data repository.

The selected historical projects were: HIS-1 (23 KLOC), HIS-2 (7 KLOC), HIS-3 (33 KLOC), HIS-4 (11 KLOC) and HIS-5 (104 KLOC).

The process

The process is a customized process as a result of blending the basic TSPi principles and the previous organizational process.

Once the new process was defined, the project started with training on the new process and the launching meeting.

The TSPi phases were used in the new process in order to get benefits from its procedures and metrics, but the intermediate products, such as requirements or design specifications, were based on the previous organizational process in order to reduce the change impact.

The focus on quality is the main difference with the previous organizational process. Examples of this approach are the quality plan relative to the phases and processes performance, inspections and reviews.

With respect to project management, weekly meetings and the earned value method were introduced. These gave to the project a real visibility and an effective tracking. The schedule, goals, risks, and change requests were evaluated in the weekly meetings.

The team was empowered to estimate and plan the project balancing the workload, and so, were more committed. Also, a good role definition was adopted.

Table 2 shows the basic TSPi principles applied in the process and the difference with the previous process.

Table 2 –TSPi principles applied in the new process

New process	Previous process
Process well defined. It makes easier the estimation and tracking project	Process with inconsistencies. The phases are not well defined
Team motivated, participative and collaborative	Only a project leader elaborates the project plan and the task distribution
Quality focus based in an early defect detection and reduction	Since the schedules are restricted, the quality was not considered
Introduction of inspection activities in the process	Only personal reviews without a quality control
Detailed plan in order to avoid schedule, and effort deviation	Projects begin with cost and schedules pre-established and restricted
Tracking and project visibility with the earned value method	There is no mechanism to track the project status
Weekly meeting to analyse the project and resolve process issues	There are no formal meetings and they are preformed only when there are problems

Verifying the project goals

In order to verify the project goals, measures were evaluated based on the initial plan (see Table 1).

5.1. Goal 1: To finish the project within the established schedule, cost and effort.

The results obtained in the project related to schedule, size and effort are (see Table 3):

Table 3 – Estimation vs. Actual

Measure	Estimation	Actual	Deviation
Schedule [SEM]	13.0	14.0	7.7%
Effort [HRA]	950.0	1121.0	18.0%
Size [KLOC]	6.9	8.5	22.5%

Table 4 shows that only there was one week of delay in the schedule. The effort can be considered acceptable because the actual value is close to the estimated value.

Table 4 – Goal 1 results

Measure	Goal	Actual	Deviation
Schedule deviation	< 8% (1 week)	7.7%	-3.8%
Effort deviation	< 15%	18.0%	20.2%
Cost deviation	< 15%	18.0%	20.2%

Cost data are derivated from effort and the results are similar.

As an example of the earned value tracking visibility, to deliver the product on time, the team decided to work with a little more intensity at seventh week because they observed a possible delay. Also, as can be seen in Figure 2, in last week (13) there was no earned value because the team was dedicated to fix a defect detected in the system test phase.

The weekly meetings and the earned value method allowed the improvement of the project management [Humphrey, 1995] (See Figure 2).

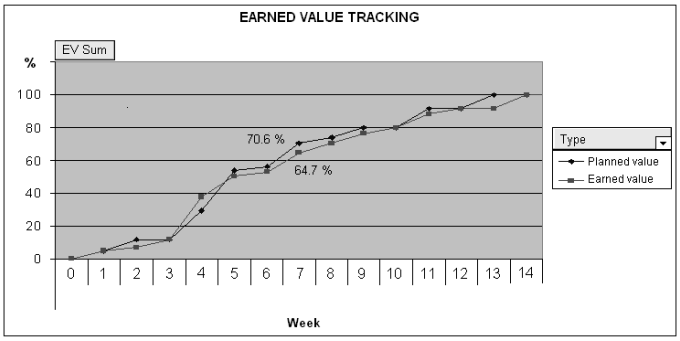

Figure 2 – Earned value tracking

5.2. Goal 2: To reduce the test time

Table 5 shows the reduction on the test time and test productivity. Note that the goal values were established using the average of the historical data

Table 5 – Goal 2 results

Measure	Goal	Actual	Deviation
Test time reduction	< 24.4 %	10.0 %	-59.1%
Test productivity [Hours/KLOC]	< 33.4	13.2	-60.5%

Figure 3 shows that the test productivity has improved 20.2 hours/KLOC, which means 60.5% better than the historical average.

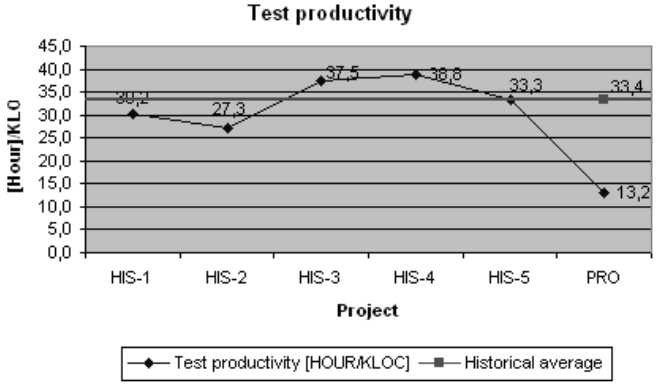

Figure 3 – Test productivity

Figure 4 shows the test time reduction. Only 10.0% of the project time was needed, which means 59.1% lower than the historical average.

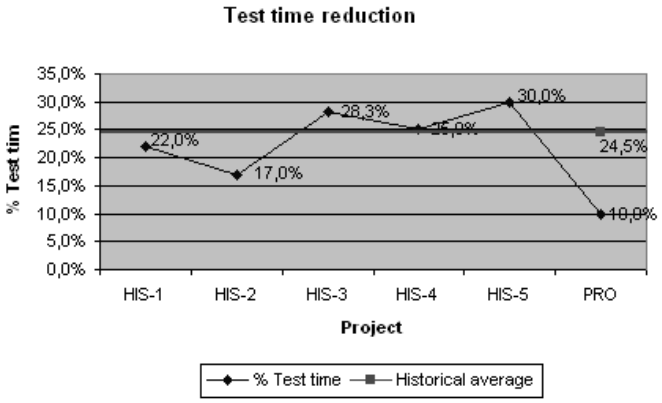

Figure 4 – Test time reduction

5.3. Goal 3: Increase the productivity and improve the product quality

Table 6 shows the project productivity and released defects goals. The project productivity had no important improvement.

Table 6 – Goal 3 results

Measure	Goal	Actual	Deviation
Project productivity [LOC/Hour]	> 7.3 %	7.6 %	3.9%
% Released defects	< 5.0	3.8	-24.8%

Figure 5 shows the project productivity improvement compared to the historical average.

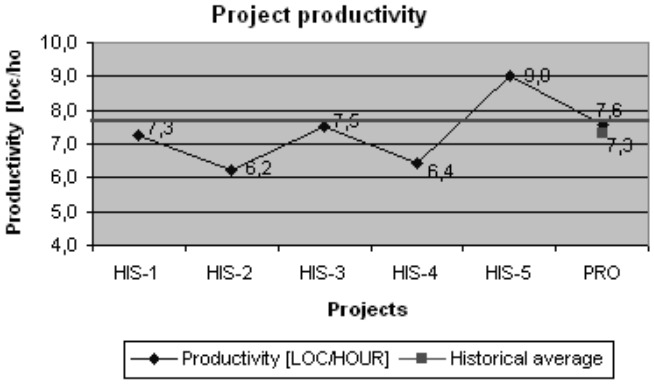

Figure 5 – Project productivity

One of the best results of this project was the reduction of the released defects. A released defect is a defect found during the first three months of operation. This was possible because the quality TSPi principles were applied, introducing reviews and inspections to get an early defect detection.

Figure 6 compares the released product defects using the new process with the historical average.

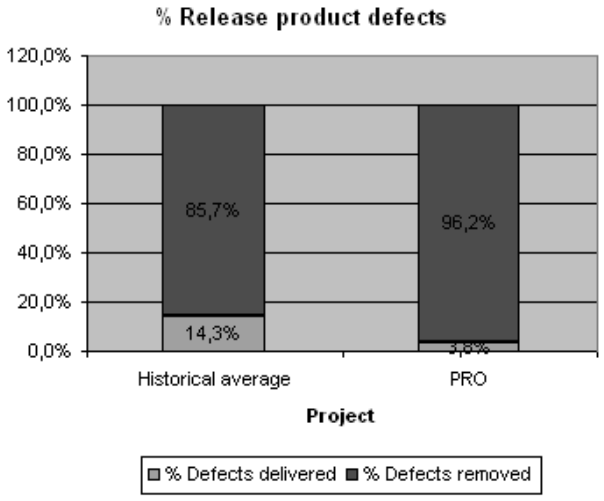

Figure 6 – Release product defects

Conclusion

The use of TSPi principles in the new process allowed the accomplishment of project goals based on the following considerations.

1. The team integration, the detailed plan, the change management, the weekly meetings and the earned value method allowed the accomplishment of these goals.
2. Along the project, the responsibility of the team members increased the test productivity by reducing the rework.
3. The reviews, inspections and quality plans allowed the reduction of test effort. The team members understood the test phase as a quality evaluation and not as a defect detection activity.

With an affordable investment in process definition, it has been demonstrated that using TSPi with adaptations has permitted a good solution for process improvement in Small Settings.

This article will be the foundation for future actions such as establishing the adapted process performance or comparing the adapted process quality versus the TSPi quality indicators.

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METADATA AND GEOSPATIAL DATA PROCESSING ON THE BASE OF XML AND GRID

Andrii Shelestov, Mykhailo Korbakov, Mykhaylo Zynovyev

Abstract: The software architecture and development consideration for open metadata extraction and processing framework are outlined. Special attention is paid to the aspects of reliability and fault tolerance. Grid infrastructure is shown as useful backend for general-purpose task.

Keywords: Metadata, ISO19115, Grid computing, Globus Toolkit, XML.

ACM Classification Keywords: D.1.3 Concurrent Programming – Distributed programming, D.2.3 Coding Tools and Techniques – Object-oriented programming, D.2.5 Testing and Debugging – Error handling and recovery, D.2.0 General – Standards.

Introduction

Metadata extraction, indexing and querying is important task from very different points of view. Consistent and actual metadata database enables effective use of data archives for users and create capabilities to develop new high-level services taking advantage of task run time prediction or automatic composition of semantic workflows. The current activities in metadata processing tools development are mainly targeting desktop indexing and search tools (Beagle, Tracker, Strigi, libferris [Martin, 2005]). However there are no available metadata processing systems that can handle geospatial data with their complex file formats, diverse metadata structure and complex queries. There is an ISO standard for geospatial metadata (described in UML) [ISO19115, 2003] as well as XML representation for it [ISO19139, 2007], but none of the available systems known to the authors take advantage of it. The approach described in this paper is targeting to fill this gap.

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Objectives

The problem of extraction, storing and querying of metadata of geospatial data is very important in the context of development of distributed geoinformational systems of national or even larger scale. The large scale systems for environmental monitoring such as international GEOSS [GEOSS, 2005] or European GMES [GMES, 2005] operate on very large sets of data and need consistent and actual catalog of metadata to operate efficiently.

The development of system being described in this paper is carried within the number of national Ukrainian initiatives such as CosmoGIS and GEOUA and international grants INTAS-CNES-NSAU #06-1000024-9154 “Data Fusion Grid Infrastructure” and STCU-NASU #3872 “GRID technologies for environmental monitoring using satellite data”. These projects and initiatives are targeting on development and exploitation of Grid infrastructure in the tasks of geospatial data processing and environmental monitoring. The problems being solved in these systems involve satellite imaginary obtained via EUMETCast data dissemination system [EUMETCast, 2006], weather forecasts data and hydrological modeling. With growth of functionality of systems in development the need for metadata catalogue and queries processing engine became clean.

The Grid technology was found very suitable for development of such system being the basis for many data processing infrastructures and stated as a technological foundation for implementation of GMES system.

After analysis of requirement authors have identified a number of functions and features that must be supported by such system.

Functions:

1. **To extract metadata from files of different formats.** Scientific data often comes in quite unusual formats that require special software that can not be found on most of computers. Examples include XRIT envelopes that are used for distribution of MSG satellite or HRPT format that is used for NOAA satellite data. Data that

are using standard container formats like HDF of NetCDF are using different field structures. These factors cause the need to utilize external handlers to process different kinds of data.

2. **To store the metadata in the queryable form in centralized storage.** The common problem of storing abstract metadata in common relational database is large diversity of data structures that is causing denormalization of relations. The proposed XML-based solution of this problem is described in the following sections.
3. **To provide interface to perform user queries.** The user should be able to query metadata with different match criteria or their combinations. The proposed query language is W3C recommended XQuery language [XQuery, 2007].
4. **To support geospatial queries.** This requirement originates from geospatial nature of satellite imaginary. Minimal set of geospatial queries functions is support for windows queries, spatial join by intersection and different coordinate reference systems.

Features:

1. **Distributed agent-server architecture.** The data that require processing can be collected on different sites of data retrieval, processing and storing facilities. The metadata extraction module should operate closely to the data to reduce unnecessary data transfers. This leads us to separation of metadata extraction part that should be deployed on the storage side from the metadata indexing and processing part that should be deployed on the separate server.
2. **Support for user extensions.** The extraction of metadata should be performed by the means of external handlers that must process specific file formats and communicate with main extractor process via defined interface. The communication interface must be kept as simple as possible to avoid unnecessary limitations on implementation of external handlers.
3. **Continuous processing.** The metadata extractor storage-side agent must detect and process new data files at the moment when they arrive on the storage.
4. **Fault tolerance.** The metadata extractor must properly handle different kinds of OS-level errors like file access errors or network unavailability and also isolate errors in external file formats handlers including incorrect resource deallocation.
5. **Access rights enforcement.** Distributed system requires features of authentication and authorization to prevent abuse of its services by unauthorized users.

The proposed solution for implementation of these functions and attributes is given in the following sections.

Analysis of XML databases usefulness

The XML databases appeared as a natural consequence of rapid growth of XML as the standard for information exchange and increasing volumes of XML documents. As opposed to relational database in their current state, XML databases have very different functionality, performance and query processing capabilities thus making the right choice difficult.

XML database differs from a relational database in a number of directions.

- Relational database uses a row (relation) as the basic storage unit, while an XML database uses an XML document.
- Instead of using SQL for querying and updating data XML databases use the pair of XQuery and XUpdate languages.
- Relational databases are generally inefficient if the entire document is needed as it may be split across tables. XML databases may be inefficient if document or a part is requested in a form different from which it is stored. In this respect XML databases are similar to hierarchical databases.
- Relational databases suits best to the situations with simple enough data structures that can be described in the terms of relations without denormalization. XML databases can be used in situation with complex data structures that can not be easily mapped to relations.

Among many different XML databases we can identify two large classes [Srivastava, 2004]:

- **XML-enabled Relational Databases.** These databases are natural evolution of traditional relational databases with new features that allows developers to combine SQL and XQuery queries. The most

noticeable examples of this class are Oracle and MS SQL Server databases. The PostgreSQL database will implement XML features in close future.

- **Native XML Databases.** These databases were designed to store XML from the scratch. The researches are very active in this area so the databases differ greatly in sense of architecture, functionality, language support and other. There are much more representatives of this class comparing with XML-enabled relational databases. Most notable are Berkeley DB XML, eXist, Sedna, X-Hive, Xindice.

XML databases are naturally suited to storing geospatial metadata information for the reasons of already existing XML mapping of ISO19115 metadata standard and complexity of metadata structure. However the requirement for ability to process geospatial queries puts very strong restriction on the choices possible.

The only database engine available at the present moment with support for both XQuery and geospatial functions is Oracle 10g. The development of metadata indexing service uses Oracle 10g under the development license. PostgreSQL developers team claims to add XQuery features in the next releases. In this case PostgreSQL will become an engine of choice for its long-available geospatial features implemented in PostGIS extension (http://postgis.refractions.net/).

Proposed architecture

The system being described consists of two parts:

- **The agent part**, that deployed on the side of data storage and performs continuous monitoring of new and changing data files. The results of monitoring are pushed to the server part. The term “agent” was chosen with respect to SNMP (Simple Network Management Protocol) agents and backup agents terminology. The agent is a special kind of server’s client that only feeds data to it without or with very little of other kinds of interaction.
- **The server part**, that deployed on the side of metadata accepts metadata from multiple agents deployed on different hosts, stores retrieved metadata in persistent storage and handles user queries.

These parts perform very different functions and thus have different implementations. The server part is implemented as a service for Globus Toolkit 4 [Foster, 2005] container. Use of Grid approach for development of such service allows us to achieve transparent integration with other applied Grid services being developed in the scope of other projects and take advantage of consistent Grid middleware services such as authentication and authorization mechanisms, monitoring and event publication.

The following features of GT4 are used:

1. **Security framework.** GT4 allows service to use PKI (Public Key Infrastructure) with loosely coupled configuration of security policy down to the granularity of specific service methods. The security framework covers “Three A” problems: Authentication, Authorization, Audit in the standard way as well as providing means for channel encryption and integration with existing security infrastructures.
2. **Index service.** This standard GT4 service allows other services to publish information about their state and to query other services information. The server part of metadata processing system using Index service to publish information about last updates and overall availability.
3. **Event publishing.** GT4 allows services to publish events and subscribe to publication in the way, similar to Observer design pattern [Gamma, 1995]. This allows other services to monitor availability and updates of metadata database and to react to specific events. Event publishing reduces the load on application server by elimination the need for periodic checks.

The Figure 1 shows the high level overview of the architecture with several metadata extractor agents, metadata server, deployed into GT4 container and some users performing requests on it.

The server receives metadata information from remote agents and puts it into persistent storage implemented as XML database. The use of XML database to store ISO19139 data granules and other metadata in form of XML documents has a number of advantages comparing with traditional relational databases systems. User requests are sent to the server in form of XQuery language. It should be mentioned that XQuery isn’t very user-friendly and simple language so the optimal solution for user interface is high-level client application (either host-based or web-based) that will interpret user request in terms of ISO19115 and put it into XQuery.

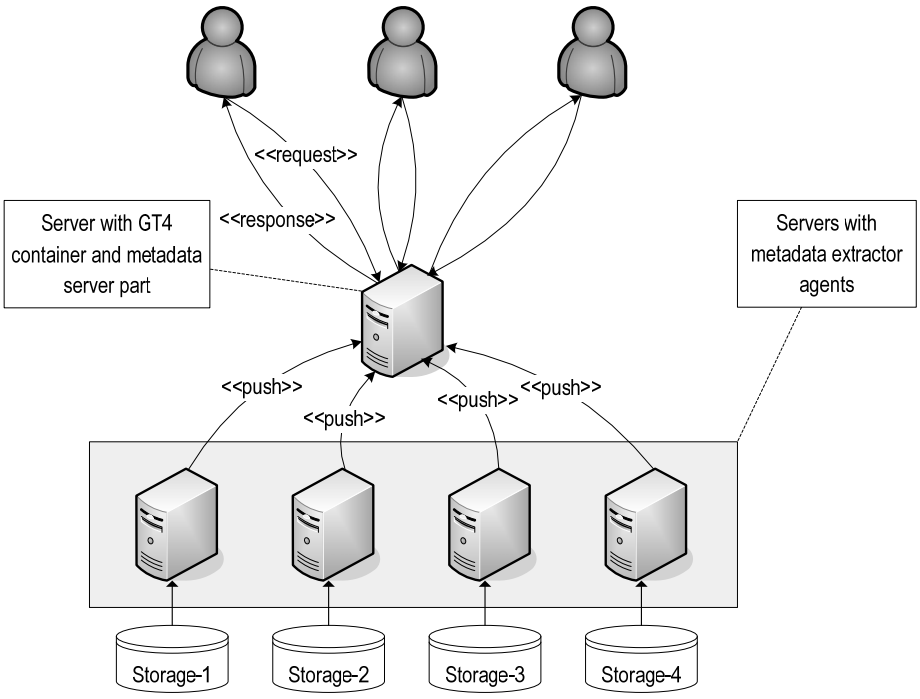

Figure 1. High-level overview of the architecture

To support clean shutdowns metadata extractor should support persistent storage for processing states of data The metadata extractor agent is implemented as a Python application for Linux environment and a set of extensions to handle specific file formats. The program uses FAM interface (File Alternation Monitor, http://oss.sgi.com/projects/fam/) to continuously monitor a number of directories specified by user, detects file format and then applies an appropriate handler.

files. At the present moment persistent storage is implemented by the means of the extended file system attributes that allows associating each file with a set of name-value pairs. Using of embedded database like SQLite or Embedded MySQL will improve compatibility of the software and will be implemented soon.

One of the design goals of the metadata extractor part was to avoid unnecessary limitations on implementation of external handlers. One of the possible ways to achieve it was to keep communication interface between the main program and extension as simple as possible. The current implementation allows every executable file put to special directory to be treated as an extension provided that it takes one command line parameter – the name of the file to process, returns valid XML document at the standard output and keeps the common agreements for the return code of a process. Such approach allows developer to choose most appropriate tool to develop a needed extension and shows zero learning curve.

The Figure 2 shows the class diagram of metadata extractor. Four classes implement the core functionality:

1. **Extractor** class is top of hierarchy and is responsible for startup of the program and construction of instances of other classes. The instance of this class is collecting information provided by DirectoryWatcher instances and sends it to server part.
2. **DirectoryWatcher** class is responsible for monitoring of a single directory in filesystem. The instance of this class starts FAM monitor and processes new files using FileHandler objects.
3. **FileHandler** class is encapsulation of external handler of file format. It responsible for running external process, retrieving the output and wrapping errors into exceptions.
4. **EAFileJournal** class is implementation of persistent storage for processing states of data files. It's implemented using extended attributes of file system.

Two composition relations marked as IPCObject represent wrapper objects that serve for interprocess communications implemented by the means of D-Bus protocol (http://www.freedesktop.org/wiki/Software/dbus) [Palmieri, 2005]. The details and reasoning of this design solution will be given further in "Reliability and Fault Tolerance considerations" section.

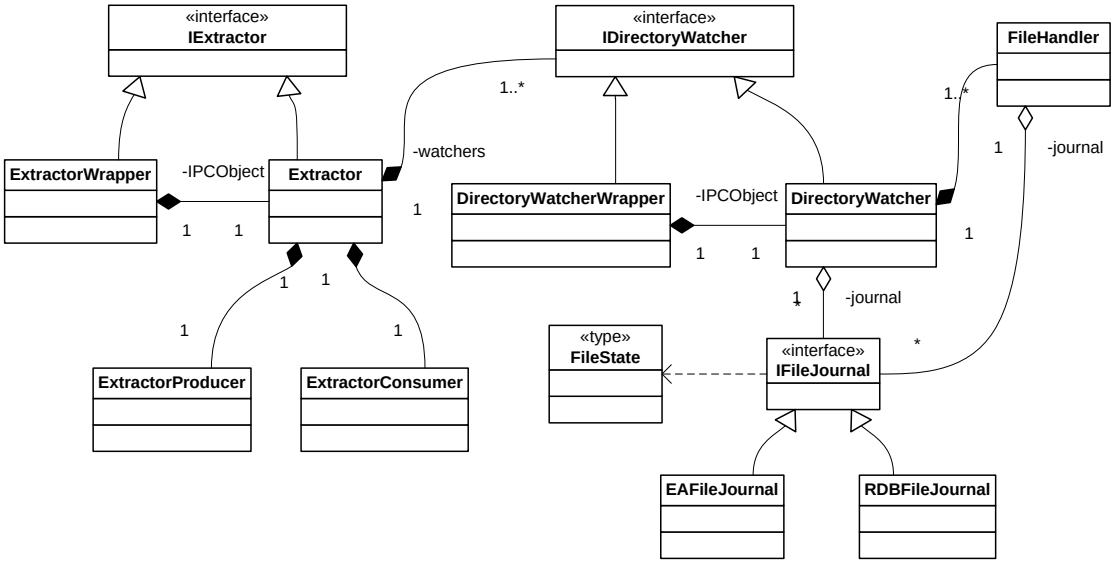

Figure 2. Class diagram of storage-side part of metadata extractor

Reliability and Fault Tolerance considerations

Reliability and fault tolerance were specifically stated in the objectives of the system. Analysis for potential faults has shown the number of sources (listed without any specific order).

- Disk read errors (SAN connectivity lost comes here too).
- Lost of network connectivity with indexing server.
- Erroneous input data.
- Exceeding of system resources (system memory is most probable candidate).
- Incorrect deallocation of resources leading to leaks.

Realization of potential fault will lead to the need of human interaction if the critical situation isn't handled in a proper way. To reduce the potential harm from these faults a number of special measures have been taken.

Disk read errors that can come either from physical hard drive fault or from lost of connectivity in storage area network do no require any special handling except proper detection of faulty situation and further periodical checks for disk availability. The same applies to the lost of network connectivity with indexing server.

Erroneous input data that is causing external file handler to crash with error should be marked as broken using persistent file state storage (FileJournal in terms of Figure 2). In those cases when input data consist of several files all of them should be declared as broken.

The exceeding of system resources and incorrect deallocation of resources is interdependent phenomena. The roots of the problem lies in the fact that the metadata extractor should run external code to retrieve metadata from different file formats. The following mechanisms were implemented to reduce the risk of crash for metadata extractor:

1. **Isolation of error.** Instead of running all of the tasks in a single process that can crash different tasks are running in separate processes. This applies both for external data format handlers and for different directories monitored by DirectoryWatcher instances (see Figure 2) running in separate process. The communication between external handlers and DirectoryWatcher instance is handled by standard output stream redirection that is very reliable. The communication between DirectoryWatcher instances and Extractor instance is performed by D-Bus interprocess message exchange system. In case of crash of process of external handler or DirectoryWatcher instance the operating system effectively frees all the system resources that crashed process have allocated. This doesn't apply to outer resources such as database connections but the use of such resource in described scenario quite unlikely.

2. **Watchdog timer.** The parent process of Extractor instance periodically checks the availability of underlying DirectoryWatcher processes via D-Bus message exchange. In case when DirectoryWatcher process doesn't reply in the specified time the process is killed and restarted by Extractor instance.

The last mechanism for supporting uninterruptible work of metadata extractor is logging system that records all relevant activities of it and can use quick contact methods such as email, IM or SMS to notify responsible person of all of system errors.

Conclusions

The authors have described the architecture of system for metadata extraction, indexing and processing targeting the geospatial data based on Globus Toolkit and XML databases technologies. The use of Globus Toolkit for such system shows a shift in the understanding of Grid systems. Authors believes that at the present moment Grid systems should be seen not only as a mechanism for supporting large computations and data transfers but also as a useful platform for value-added tasks.

Acknowledgments

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USING THE BUSINESS PROCESS EXECUTION LANGUAGE FOR MANAGING SCIENTIFIC PROCESSES

Anna Malinova, Snezhana Gocheva-Ilieva

Abstract: This paper describes the use of the Business Process Execution Language for Web Services (BPEL4WS/BPEL) for managing scientific workflows. This work is result of our attempt to adopt Service Oriented Architecture in order to perform Web services – based simulation of metal vapor lasers. Scientific workflows can be more demanding in their requirements than business processes. In the context of addressing these requirements, the features of the BPEL4WS specification are discussed, which is widely regarded as the de-facto standard for orchestrating Web services for business workflows. A typical use case of calculation the electric field potential and intensity distributions is discussed as an example of building a BPEL process to perform distributed simulation constructed by loosely-coupled services.

Keywords: BPEL, scientific workflows, Web services, SOA.

ACM Classification Keywords: D.2.12 Interoperability - Distributed objects

Introduction

There is growing interest in the use of Web services infrastructures for scientific computing. Web services provide interoperability of various applications running on heterogeneous platforms. They enable dynamic connections and automation of business processes within and across scientific collaborations for application integration, reusability, and flexibility which is motivated mainly by the loosely coupled nature of the Web services. Web services became the preferred way to realize Service Oriented Architectures (SOA). SOA is architecture that represents software functionality as discoverable services on the network. All program functions and methods are exposed as services described by some universal description language (WSDL [1] in the case of Web services-based SOA). These interfaces can be invoked by other services to perform business processes.

The Business Process Execution Language (BPEL) [2] is an XML-based language used for integration of a number of Web services into more complex composite services. Thus BPEL enables the top-down realization of Service Oriented Architecture through composition, orchestration, and coordination of Web services. The BPEL composite services are called business processes and are managed by a workflow engine. BPEL processes orchestrate the interactions between the Web services using standard XML (SOAP) messages for communication. BPEL processes can be executed on any platform or product that compiles with the BPEL specification. BPEL supports the Web services technology stack, including SOAP, WSDL, UDDI, WS-Reliable messaging, WS-Coordination, and WS-Transaction.

This paper describes the use of BPEL for managing scientific workflows. The complex, unpredictable, and inter-dependent nature of the components in a scientific workflow leads to such requirements, concerning workflow language, as exception handling, recovery from uncertain situations, user interactions to facilitate interactive steering and monitoring, flexibility to support dynamic selection of services at runtime, etc. In the context of addressing these requirements, the BPEL specification features are discussed in the following sections.

We use BPEL to orchestrate Web services in order to perform simulation of metal vapor lasers. This includes providing of Web services wrappers of legacy scientific applications. We begin our workflow solution by defining a number of inter-related patterns that match the basic requirements of the users of the system. A typical use case of the calculation the electric field potential and intensity distributions is also provided as an example of building a BPEL process to perform distributed simulation constructed by loosely-coupled services. The BPEL processes we build are realized with the Oracle BPEL Process Manager and Designer and are deployed to the Oracle Application Server.

Scientific Workflows and BPEL4WS

The spectrum of what might be called scientific workflow is wide and includes scientific discovery workflows, workflows that automate manual procedures or reengineer custom tools, and data and compute-intensive

workflows. Scientific workflow support is needed for practically all information-oriented scientific disciplines, including bioinformatics, chemistry, ecology, geology, physics, etc. In this section we provide a number of common requirements of scientific workflows: service composition and reuse, scalability, detached execution, reliability and fault tolerance, user interaction, monitoring, "smart" re-runs, data provenance, etc. ([5], [6], [7]).

In general, the BPEL vocabulary is tailored more to the requirements of business processes, which often have different requirements compared to scientific workflows. For example, in [5] is outlined that business workflow approaches focus on control-flow patterns and events, whereas dataflow is often a secondary issue. Scientific workflow systems, on the other hand tend to have execution model that are much more dataflow-oriented.

In this section we provide an analysis of the BPEL specification in the context of the above listed requirements. We do this also in the context of the implementation technology we have adopted, particularly the Oracle's BPEL Process Manager as part of the Oracle SOA Suite.

Service composition and reuse.

Web services can be combined in two ways: orchestration and choreography. In orchestration a central process (which can be another Web service) takes control of the involved Web services and coordinates the execution of different operations. The involved Web services do not "know" (and do not need to know) that they are taking part in a composition process. Choreography, in contrast, does not rely on central coordinator and occurs in pear-to-pear style workflows where communications occur directly between partners. All participants in the choreography need to be aware of the business process, operations to execute, messages to exchange, and the timing of message exchanges.

BPEL supports two different ways of describing business processes that support orchestration and choreography: Executable processes - they follow the orchestration paradigm and can be executed by an orchestration engine; Abstract business protocols - they allow specification of the public message exchange between parties only. They do not include the internal details of process flows and are not executable. They follow the choreography paradigm.

From the perspective of composing Web services to execute scientific processes, orchestration is a more flexible paradigm and has the following advantages over choreography:

- The coordination of component process is centrally managed by a known coordinator.
- Web services can be incorporated without their being aware that they are taking part of a larger process.
- Alternative scenarios can be put in place in case faults occur.

Scalability.

Some scientific workflows involve large volumes of data and/or require high-end computational resources, e.g. running a large number of parallel jobs on a cluster computer. To support such data-intensive and compute-intensive workflows, suitable interfaces to Grid middleware components are necessary.

Parallel flows enable a BPEL process to perform multiple tasks at the same time, which is useful when we need to perform several time-consuming and independent tasks. Concurrency is provided with the <flow> activity which causes all the activities nested within it to be executed concurrently. Control exits from <flow> when all nested activities terminate.

BPEL also provides features to support handling multiple requests. Multiple customer interactions can be handled concurrently by creating multiple instances of the process, one for each interaction. This is not a problem if the interaction consists of a single, synchronous invocation of an operation on a server, and the server does not invoke other servers in the process of handling the request. Scientific processes, however, often require long running conversations and transactions between partners. For workflows, this involves the addition of process identifiers that are embedded and exchanged between partners during a conversation. For handling such situations, BPEL allows a process to declare a *correlation set* local to a scope. This is a set of properties such that all messages having the same values of all the properties in the set are part of the same interaction and hence are handled by the same instance. Thus, a correlation set identifies a particular instance of among a set of instances of that process, and a correlation set and a port together uniquely identify a process instance among all process instances at a host machine.

Detached execution.

Long running scientific workflows require an execution node that allows the workflow control engine to run in the background on a remote server, without necessarily staying connected to a user's client application that has started and is controlling workflow execution.

In a BPEL process a web service can be invoked as a synchronous or asynchronous operation. Synchronous web services provide an immediate response to a query, and block the BPEL process for the duration of the operation. Asynchronous web services do not block the BPEL process, and are useful for environments in which a service can take a long time to process a client request. Asynchronous services also provide a more fault-tolerant and scalable architecture than synchronous services.

Reliability and fault tolerance.

A scientific workflow might incorporate a service that often "fail", change its interface, or just become unacceptably slow. Thus the workflow definition should support the definition of failure handling mechanisms.

BPEL provides a flexible structure for dealing with failures. Fault and compensation handlers are used to reverse the effects of partially completed interactions. The execution of these handlers is tied in with the concept of scopes. A scope serves to define the execution context of an activity. A scope can have a name and local declarations and encloses (possibly complex) activity to be executed. Declarations include, among other items, local variables, fault handlers, and a compensation handler. Compensation applies only to scope's external effects – the effects it has invoked at other sites. On entry, a scope's compensation handler is given a snapshot of the process's state at the time control exited (normally) from the scope. Since it can access only the snapshot and not the variables themselves, compensation cannot affect the state of the process and applies only to external activities. Faults signal failure and start the process of reversing the effects of an interaction. A fault might be raised in a process if it gets a fault response to an operation that it has invoked synchronously. Alternatively, a process might explicitly execute a <throw> activity if it recognizes that an anomalous situation has arisen.

User interaction.

Many scientific workflows require user decisions and interactions at various steps. An interesting challenge is the need for user interaction in a detached execution. Using a notification mechanism the user might be asked to reconnect to the running instance and make a decision before the paused (sub-) workflow can resume.

BPEL 1.1 and 2.0 do not include human interactions and are limited to service orchestration. Oracle BPEL Process Manager provides manual task Web service to integrate people and manual tasks into BPEL processes [8]. By implementing this as a true BPEL service, the interface to the task service is described with WSDL and people can be included in 100% standard BPEL processes – to the BPEL process, the person/manual task looks like any other asynchronous Web service. User notification is also supported – anything that can be done in BPEL (invoking a Web service, sending an e-mail message or JMS message, executing some Java code, and so on) can be done to notify a user of a task-related event.

Monitoring.

Scientific workflows are potentially long running activities and it is of importance to scientists to be able to observe and monitor the ongoing execution of a workflow.

Oracle BPEL Manager provides sensors to monitor BPEL activities, variables, and faults during runtime [8]. The following types of sensors can be defined, either through the BPEL Designer or manually by providing sensor configuration files:

- Activity sensors: Used to monitor the execution of activities within a BPEL process. For example, activity sensors can be used to monitor the execution time of an invoke activity or how long it takes to complete a scope. Along with the activity sensor, the variables of the activity might be also monitored.
- Variable sensors: Used to monitor variables (or parts of a variable) of a BPEL process. For example, variable sensors can be used to monitor the input and output data of a BPEL process.
- Fault sensors: Used to monitor BPEL faults.

The following two requirements are much desirable for scientific workflow systems, although difficult to implement:

"Smart" re-computations.

A special kind of user interaction is the change of a parameter of a workflow. A "smart" re-computation (re-run) would not execute the workflow from scratch, but only those parts that are affected by a parameter change.

Another useful technique in this context is the ability to backtrack (in the case or parameter change or even a system failure) to a previously saved state without starting over from scratch.

Data provenance.

Computational experiments and runs of scientific workflows should be reproducible and indicate which specific data products and tools have been used to create a derived data product. A scientific workflow system should be able to automatically log the sequence of applied steps, parameter settings and intermediate data products. A related requirement is automatic report generation: The system should allow the user to generate reports with all relevant provenance and runtime information, e.g., in XML format for archival and exchange purposes, and in HTML (generated from the former, e.g., via a XSLT script) for human consumption.

While the above list of requirements for scientific workflow systems is by no means complete, it should be sufficient to capture many of the core characteristics. Other requirements include the use of an intuitive GUI to allow the user to compose a workflow visually from smaller components to animate workflow execution, to inspect intermediate results, etc., although these requirements are not related with the BPEL specification itself. Rather, they depend on the BPEL Designer and engine vendor.

Basic Patterns of the Workflow Solution

In this section we define a number of inter-related patterns that match the basic requirements of the users of the Web services-based system for simulation of metal vapor lasers we are in process of developing. Our approach is to decompose the simulation processes into a collection of basic patterns that can be fully automated. These are hierarchically organized, as they are co-dependant, as presented in Figure 1:

- Simulation execution and monitoring pattern: This is the most basic workflow pattern. It presents the ability to submit a simulation, monitor its execution, and handle any potential faults (which may include resubmitting the job if needed).
- Data retrieval and storage pattern: Adds to the above the capability of retrieving data from the data storage before job submission and uploading results to the storage upon completion.
- Metadata management: Generated metadata for the created file, and uploading these to the metadata storage.

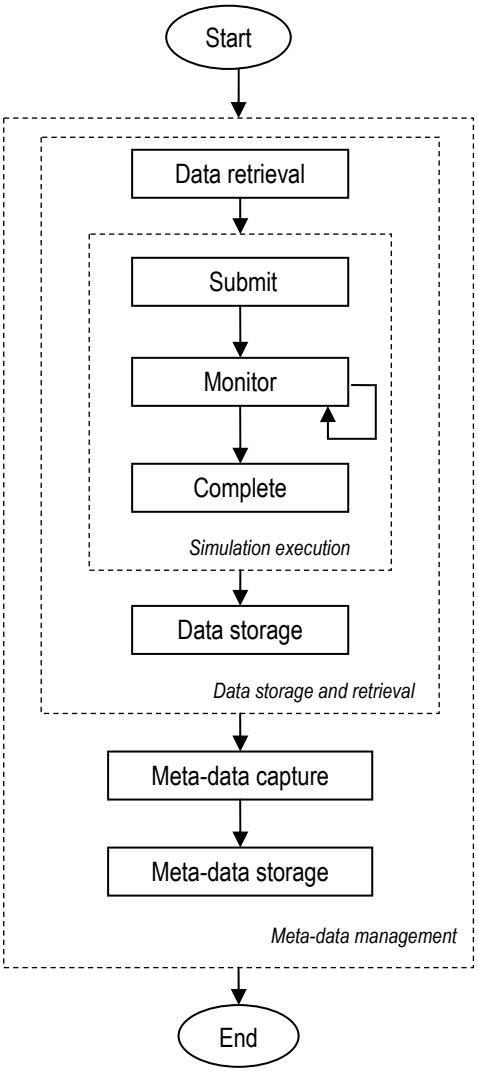

Figure 1. Basic simulation workflow patterns.

This hierarchical organization maps well to BPEL-base workflows. Because these are themselves presented as Web services, it is possible for a workflow to incorporate other workflows into its structure. Not all capabilities presented, such as metadata capture, may be required for every job of the scientific process that the user wishes to execute. This hierarchical approach also favors reusability and enables the potential addition of new services and its incorporation into larger workflows.

A data/metadata management tools will be integrated with the workflow tools using web services technology. This integration is essential to allow the automatic collection and publishing of metadata relating to the simulations along with efficiently handling the data files themselves.

A Typical Use Case

In this section we describe an example workflow for calculation of the electric field potential and intensity distributions of the radio-frequency discharge in He-Cd laser. The obtained results are necessary for further investigation of the dependence between different laser characteristics, oriented for practical engineering purposes in order to improve the total efficiency of the real He-Cd laser.

We have wrapped legacy FORTRAN codes as Java modules trough the use of the Java Native Interface [3]. Then we have transformed these modules into Web services. These are:

- "Electrode" Web service – for a predefined geometry of the 2D cross-section of the laser design this module generates the appropriate mesh for discretization and classifies the points in the different sub-regions: outer electrodes, laser tube, etc. Basic input parameter is the applied to the electrodes voltage, which is then used to determine the boundary conditions.
- "Poisson" Web service – This module provides numerical solution of the Poisson equation with which we model the potential equation.

The BPEL process first invokes a synchronous "GetData" service to retrieve data from the data storage. The data retrieved is a number of parameters predefined for the chosen laser type. These parameters are stored natively in XML files. An XML schema was created to describe these parameter sets. It consists of two types: *parameterset* and *parameter*. The type *parameter* is an abstract type which all parameters extend. Thus we can manage different parameter sets relevant to different laser types, as well to have different parameter set instances of a particular laser type. We have also created an Oracle's BPEL Manager Human Workflow Task service to incorporate a user task in the BPEL process and particularly the parameter approval. This enables the user to change some of the predefined values of physical constants, geometrical parameters, etc.

Then the "Electrode" service is invoked synchronously. The service creates output file which is next used as input for the "Poisson" service to calculate the electric field intensity and to save the output in a file.

Conclusion

From our work so far we conclude that BPEL is fully applicable for orchestrating scientific services. Furthermore BPEL could serve as a standard representation for scientific workflows and hence aid reproducibility. In addition the Oracle BPEL Process Manager, which we use, has built in support for the use of Web Services Invocation Framework (WSIF) [4]. Thus a direct Java code injection into a workflow script is enabled. This is a possible way to overcome some of the limitations of BPEL specification.

Acknowledgments

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DEVELOPMENT OF THE COMBINED METHOD FOR DESIGNING DATAFLOW SYSTEMS

Nina Bakanova, Tatiana Atanasova

Abstract: The methods of designing of information systems for large organizations are considered in the paper. The structural and object-oriented approaches are compared. For the practical realization of the automated dataflow systems the combined method for the system development and analysis is proposed.

Keywords: designing of information systems, document circulation, dataflow, office-work

ACM Classification Keywords: D.2.2 Design Tools and Techniques: Computer-aided software engineering (CASE); H.4 Information Systems Applications: Workflow management

Introduction

The informatization of the administrative activities in large organizations is inseparably linked with the use of the automated systems for ensuring of document circulation. Frame functions of dataflow systems are defined by the norms for management of documentary maintenance (MDM), as automation of technological processes for passing, processing and control of execution of documents. At that in each concrete organization these systems accompany the main primary activity and, apart from the listed functions, include functions connected with the specificity of branch of management [Brooks, 2000].

Thus, designers of information systems are compelled to investigate the specificity of the document circulation in the given organization, the characteristics of procedures for acceptance of administrative decisions and many other factors that influence on the functional features of the information system.

The development of the projects for large-scale information systems (IS) with complex architecture is impossible without the use of special methodologies and the automated instrument tools providing support for the processes of designing, realization and functioning of the IS.

Such tools are the program complexes for automated design or CASE-tools (Computer Aided Software Engineering). They are intended to reduce laboriousness and durability of the information system design owing to realization of special languages for designing and creation of collective means of system engineering.

Problem formulation

The development of the project for dataflow information system in a large organization requires choosing appropriate methodology for system designing that can provide the most effective work on revealing functional tasks and structure of the system. During the selection of this methodology it is required to take into consideration, that the work will be carried out both by experts-analysts and by specialists in the applied area which are not familiar with the methodology and methods of the IS designing.

According to the systematic approach *(Structured Analysis and Design Technique SADT)* the automated information system represents a set of interconnected objects (elements) that are functioning together for a shared purpose [Марка, 1997].

The existing design methodologies realize the representation of the interconnected objects by using various graphical notations for the creation of visual models. At sufficient depth of the development work the visual model allows to present clearly not only the internal structure of the system, but also to reflect the basic features of its functioning.

Two basic approaches are the best known in the methodology of the system designing, as the fundamental distinction between them comes from the various ways of providing for system decomposition [Maklakov, 2003, Vendrov, 2003].

The Functional-modular or **the structural approach** is based on the principle of functional decomposition at which the model of the system is described in terms of hierarchy of functions and information transfers between separate functional elements.

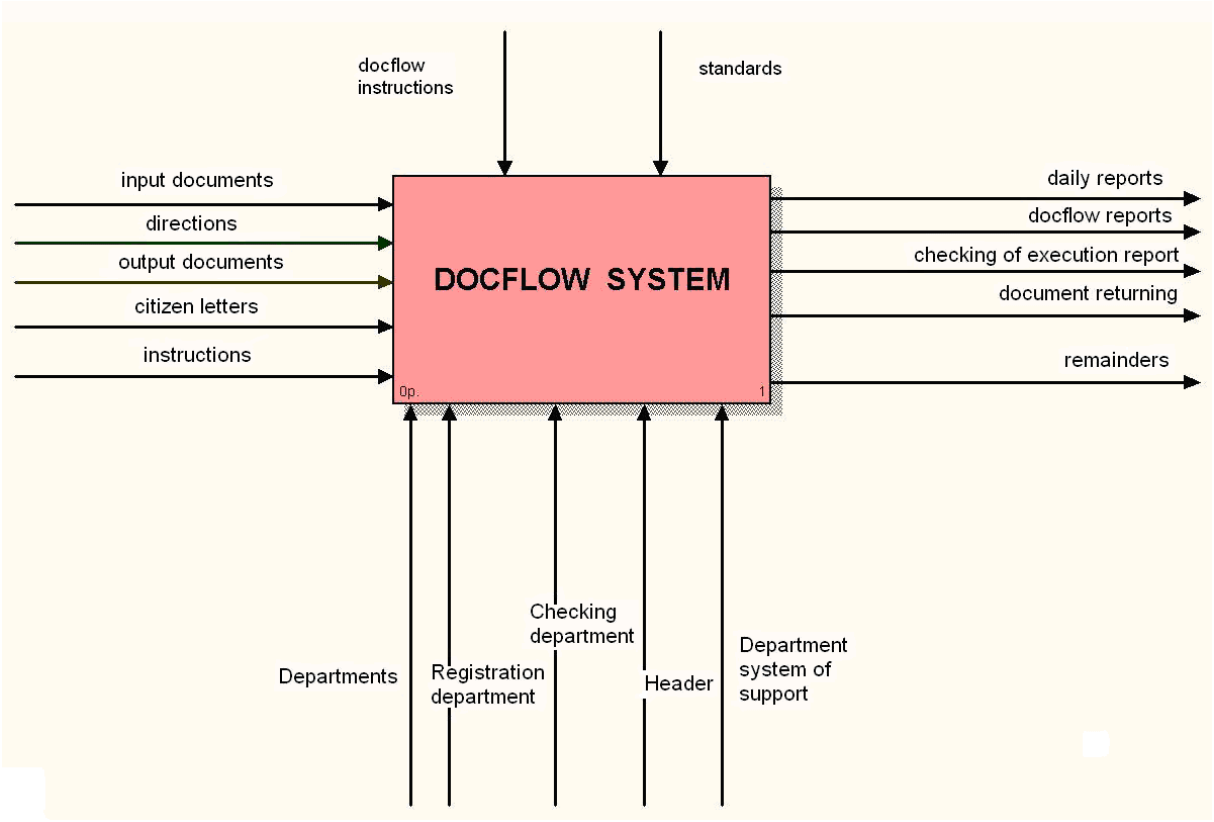

Fig. 1. The dataflow system with external world relations

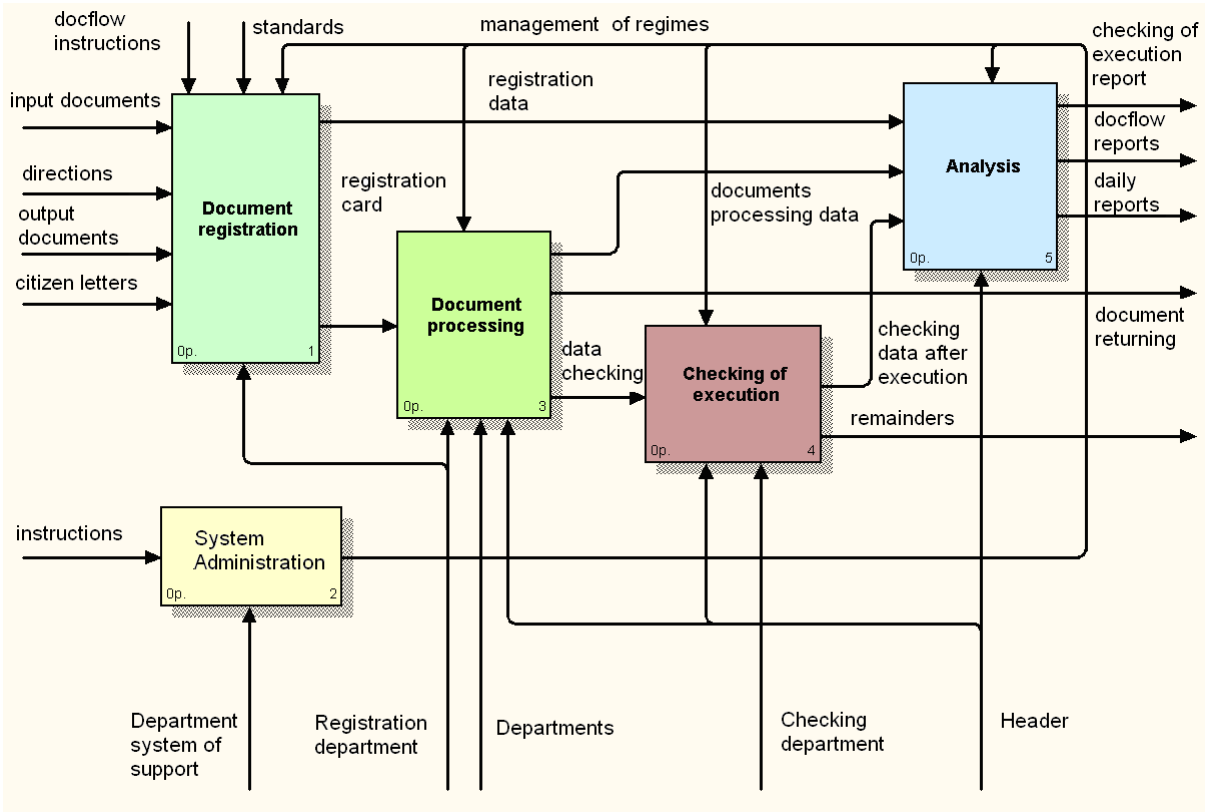

Fig. 2. The first level of dataflow system diagram decomposition

In figures 1 - 2 the fragment of representation of dataflow system in the form of its functional-modular diagrams is presented. In figure 1 the system as a whole and its relation to the external world is shown. Figure 2 describes the first level of system decomposition.

At the **object-oriented approach** the object decomposition is used. In this case, the structure of the system is described in terms of objects and relations between them. The behaviour of the system is described in terms of messages exchange between the objects [Vendrov, 2003, Booch, 2000].

The advantage of the functional models is the realization of the principle of "top-down design" that corresponds to the traditional representations of hierarchical functions in the organizational control systems [Belyev, 2000].

The disadvantages of the structural approach are complex conversion to the design of data structure and software; the necessity to use other methods and, accordingly, packages of automation.

For example, for the representation of models of the data, the developed program system requires the use of diagrams "essence – communication" *(Entity-Relationship Diagram – ERD),* but for the definition of external references and data storage other diagrams of dataflows *(Data Flow Diagram – DFD)* have to be used. The use of various kinds of diagrams complicates the work of the designers and accordingly increases the time for the project development.

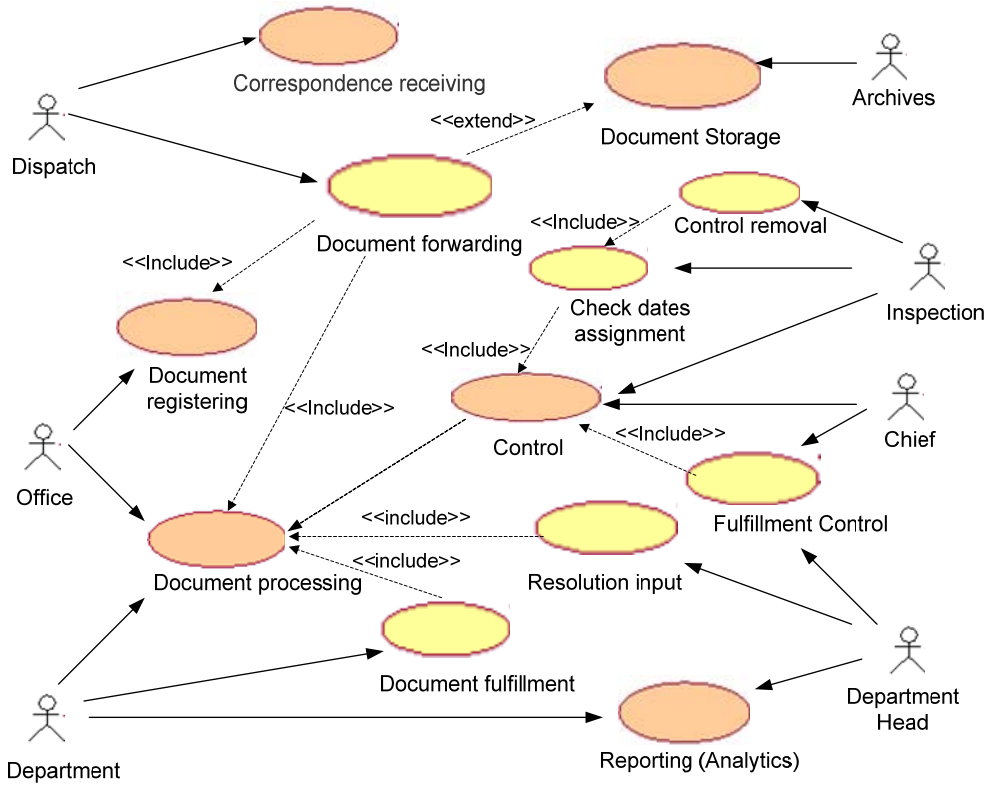

Fig. 3. USE-CASE diagram

The object-oriented approach (OOA) is a more progressive methodology. It is based on the object model representing the real world in the form of a set of cooperating objects. The methodology of the OOA is grounded on the principles of abstraction, modularity and polymorphism. The coordination of models of the projected system at all stages of its development is a requirement of the object-oriented approach [Booch, 2000].

For the realization of the object approach in the form of CASE-means, a special language for designing - UML (Unified Modelling Language) is developed. The UML language is a powerful instrument of designing and it is intended for use by highly skilled experts - designers of information systems [Ларман, 2001], but it is difficult enough to find common language with experts from the applied area.

On figures 3 - 4 examples of OOA diagrams are presented. In figure 3 the diagram of variants of use for dataflow system (USE-CASE) is shown. This diagram illustrates well requirements to the system, but does not show functional relations. In figure 4 the classes diagram is shown which reflects functional relations, but it is too complex for people not familiar with the UML language.

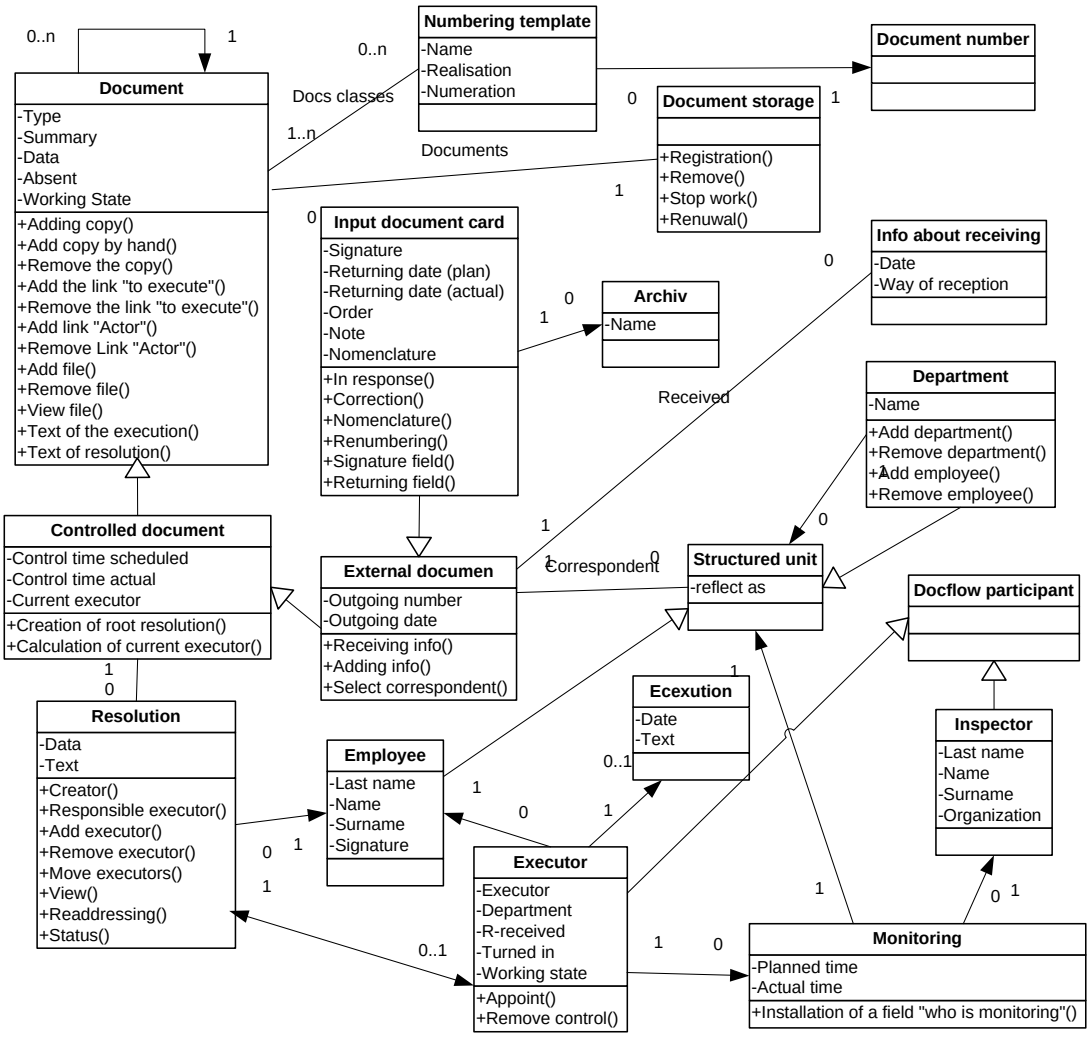

Fig.4 Classes Diagram

Variant of the solution

As the analysis of *hopeless projects* [Парман, 2001] shows, the basic mistakes in the designing arise at the stages of the conceptual project, at the coordination of the functions of the system with the experts of applied area, at the determination of the limits of the system and the consideration of its development perspectives.

The main objective for the application of the CASE – technologies is to supply all of the participants in the project with common language of "understanding". A combination of both the structural and object-oriented methods appears to be the most effective way for achieving this objective.

At all advantages of OOA, the most critical and labour-consuming parts in the given approach remain making the correct choice of needed objects and their further development. The criteria for the choosing of appropriate objects are based first of all on the principles of reusing and optimization of construction of the system's software complex. These principles are far beneath to be obvious for the experts from a subject domain. On the other hand, certain difficulties can arise for experts - analysts from the applied area, which can have a lot of particularities that are not appreciable at first sight. The structural diagrams are simpler for understanding and allow performing the analysis of necessary functions of the system.

Having in mind these problems and standing on the basis of the available experience of the development of large systems [Баканова, 2003], it was proposed (in order to ensure a dialogue with experts of a subject domain and prompt studying of the features of the created system), at initial stages of designing to use the structural approach. This will provide:

- precise delimitation of the system;
- definition of input/output streams of information (contextual diagrams);
- process of designing of functions "from top to down", that corresponds to the traditional representations of the hierarchical organization of work;
- an opportunity for construction variants of logic schemes for documents processing ;
- functional detailed elaboration of procedures for documents processing which allows to reveal shortcomings of existing processes (useless, uncontrollable and duplicated works).

In the combined method it is offered to conduct the coordination of the two types of diagrams: functional diagrams and diagrams of logic level OOA after functional decomposition executed up to a level of logic operations. It allows using as much as possible knowledge of experts from the applied area for revealing all necessary functions and construction of the consistent project for the system.

The process of objects allocation for OOA is caring out on the basis of the already developed specifications after the work with functional diagrams is done. Such approach has shown good results at designing systems for automation of document circulation in large organizations in which subject domain experts were specialists on the office-work, not familiar with the existing designing technologies.

Conclusion

For achieving the most effective utilization of expertise from a subject domain at the construction of large information systems it is offered to use the combined method of designing in which at the initial stages it is recommended to apply the structural approach. The next step in the designing procedure should be the preparation of specifications on all stipulated works of the structural approach for revealing objects and transition to the OOA.

The specified combined method of designing has been used for creation projects of dataflow systems for a diversity of large organizations, including: Presidium of the Russian Academy of Science, the Ministry of transport of the Russian Federation and others.

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SOFTWARE TESTING AND DOCUMENTING AUTOMATION

Anton Tsybin, Lyudmila Lyadova

Abstract: This article describes some approaches to problem of testing and documenting automation in information systems with graphical user interface. Combination of data mining methods and theory of finite state machines is used for testing automation. Automated creation of software documentation is based on using metadata in documented system. Metadata is built on graph model. Described approaches improve performance and quality of testing and documenting processes.

Keywords: software testing, documenting automation, data mining, dynamic grammar, metadata.

ACM Classification Keywords: D.2 Software Engineering: D.2.2 Design Tools and Techniques; D.2.4 Software - Program Verification; I.2 Artificial Intelligence: I.2.2 Automatic Programming.

Introduction

Lifecycle is the basic concept of software design methodology at the moment. Lifecycle is permanent process that starts from making a decision of creation software system and ends after getting out it from operation.

Lifecycle consists of three groups of processes: main, auxiliary and organizational. Main group includes these steps: creation, set in operation and exploitation, maintenance.

Software creation is also complex step. It includes: lifecycle analysis, software requirements analysis, components structure design, project implementation.

Control testing and acceptance evaluation are realized at the step of information system application and at the adaptable information system exploitation stage. The main goal of this process is software quality assurance.

All described steps of software system creation include auxiliary process of documenting. Documenting process suggests creation of different user instructions and manuals, user and developer documentation.

Software requirements analysis and object model design are the most formalized steps and the most supported by variety of automating tools. Testing and documenting processes are less equipped with automation software. This regularity is peculiar to small software companies. The reason of this peculiarity is complexity of software testing and documenting automation. In spite of plenty of automation software, there is no universal program that suits to any domain. Manual testing and documenting require significant amount of time and funds, but small companies do not have it. However, testing is very important step in software lifecycle, because ignoring it leads to low-quality, malfunctioning software. The Institute of Illinois offered model for measuring of testing automation degree in software lifecycle. This model is called TMM (Test Maturity Model), [1]. It includes a number of methods for improving the testing automation degree.

Documenting process is ignored by many organizations particularly at the final stages of software creation. It harshly decreases efficiency of information system application and maintenance, because it's too hard to change source program code or object model of information system without descriptions of the software functions and requirements when malfunctions are found or system is moved to new hardware architecture or software environment.

Testing and documenting stages become more complicated when user documentation is absent or manuals are made too bad. It leads to decreasing of user leaning efficiency. Therefore variety of data input mistakes and questions to technical support service appear.

Approaches to Software Testing

There is great supply of software intended for automation of programs developing process on the market now. This software automates different stages of program lifecycle. In particular testing of the developing programs at the different stages of a project is important for developers. There are many programs among testing software that verify completeness and consistency for requirements, network interaction and main program functionality

with black-box, white-box and grey-box conformance methods. System reliability under load and overload is testing too. There are a couple of testing programs that also can automate user interface usability testing.

The first method in history of testing was so-called *black-box* testing approach [2]. Black-box testing is suitable for small program modules and is hard to use for complex software systems, because it requires to run many tests to ensure that software system works correct.

New approach for testing in a workmanlike manner was offered by Antony Hoar – *program correctness proof method* [3]. Only one severe weakness of correctness proof was extraordinary complexity of mathematical models construction for big programs. This method was refused after several unsuccessful attempts of applying.

Later some other testing methods based on *revealing errors by source code analysis* were offered. *White-box* conformance testing is well-known method. It was described by Fillis Frankl and Elyne Weyker in 1988 [2]. Common disadvantage of white-box testing is that testing process does not have any information on requirements; therefore there is no information on right results of calculations. So testing software cannot define whenever verified program gave correct results. Thus the results of calculations must be verified manually. The problem is that white-box method uses code coverage and thus it generates plenty of test cases, so it would be impossible to verify them manually. To solve this problem *N-selective test case method* was offered. N-selective test case is based on statistical methods.

Separate group of testing software makes up so-called *record-playback programs*. These programs can record user actions (mouse clicks, key presses etc) and playback them in a user like manner later. For example Rational Robot record-playback program allows checking result correctness with windows controls properties.

Original approaches combining benefits of several testing methods systems exist. These methods make good use record-playback. For example article [4] describes original approach for testing program's graphical user interface. The main disadvantage of this approach is interface state diagrams creation and maintenance complexity.

Approaches for Automatic Documentation Creation

Now the main part of documenting automation software on market is filled up with source code documenting systems. Let's look some of those systems over.

All systems for automatic generation of program documentation use same idea based on grammars. By word "grammar" we will understand any formalized rule set which describes system architecture.

Testing Systems with Fixed Grammar

The majority of modern code documenting systems uses fixed grammars. The idea of fixed grammars is to *extract document information from programming language syntax*. The set of rules that describes programming language syntax is also called *programming language grammar*. These rules are fixed in programming language specifications and thus they cannot be changed.

Let's look at NDoc system as an example. This system is aimed at source code documenting automation for Microsoft dotNET platform. In this example fixed grammar is the set of rules that defines structure of object-oriented program in dotNET and also that describe how to process XML-tagged comments in source code.

The same idea is used by JavaDoc – system for automatic documenting of projects in Java language.

Also there are automatic documenting systems for specific programming languages. LpDoc system generates documentation for List and Prolog languages. Accordingly this system uses grammar that consists of syntax and semantic rules of these languages.

Testing Systems with Dynamic Grammar

Projects documenting automation system based on finite state machines theory is described in [5]. This system allows creating documentation in middle format that can be converted to finite documentation in target format at any time. The idea of saving document data in intermediate format is also used in this research work.

Developer or user creates special templates. Each of templates is the base for documentation. Template includes document structure information. So this documenting system uses grammar made of rules intended for extracting information from file with well-defined structure. The difference from systems based on fixed grammars is that information extracting rules are stored in XML-files outside of documenting system and thus they can be changed at any time forcing the system to change its logic of making documentation.

New Testing and Documenting Automation Methods

This research is given up to testing for GUI programs and automatic generation of user documentation for information systems.

GUI systems were chose for testing automation because most systems now implement graphical user interface. User documentation includes system functions description and step by step instructions of typical operations throw GUI. Thus it is necessary to verify system automatically throw GUI and then generate user documentation on basic functions. Documentation must contain images of user forms from that GUI.

The main problem of testing is to still description of rules which set verifying program's behavior. While small programs for scientific calculations need about 10-20 rules to describe behavior the number of rules describing behavior of complex software systems exceeds hundreds of thousands. In spite of white-box method has some advantages in automatic test cases creation this method can not verify correctness of test execution result automatically. White-box method can do verification of testing results only if a set of rules defining program logic specification exists or somebody can manually check the results.

The concept of researching testing method is based on gathering statistics of some parameters values during program testing. Internal program variables and visual controls properties may be chosen as parameters. Original approach described here is more common than another one which is used by Rational Robot testing system (Rational Robot system does not allow to monitor internal variables values for program under testing).

Source code of program under testing may be used for automatically generating input values for visual interface. For example there is a way to generate several test cases for visual controls using control-flow or data-flow coverage criteria that program's source code will be completely verified. User is required just point out a set of internal variables to verify result correctness.

Input values for interface can be generated with using random values, but it will be less efficient than white-box testing because it isn't aimed at source code bottlenecks.

Testing system collects statistics on selected parameter's values and events of state transitions (like in finite state machines) during program execution. It is necessary to find a way of checking out if each test case returned correct result because we don't have program specification. Data mining method is proposed to solve this problem.

Fuzzy method is selected to identify correctness of test execution because making a program specification is a hard work. This kind of methods is suitable for knowledge extracting from testing results. In other words, we can try to reveal some regularity, associations, dependencies, and sequences in testing results without any manual work. Different conclusions based on exception cases, anomalies in testing results can be made. Also fuzzy methods allow applying criteria for selecting some tests to be verified manually. So testing system will give several tests to be verified by user after making and executing hundreds of test cases throw graphical interface. User returns results back to the system after manual testing and testing system can take this information into account when searching for regularities.

Among data mining technology these methods are suitable for using in testing:

- *Limited selection algorithm*. It checks simple logic events in different data subgroups. Logic events are chosen by heuristic.
- *Associations revealing algorithm*. It recalculates confidence factors for facts combinations based on Bayesian conditional probability and chance.
- *Statistical methods*. They use average values to check distribution statistical parameters, in random distribution hypothesis proving, linear correlation checking.
- *Neural network*. It approximates dependencies by using nonlinear functions.

Program variables dependencies and dependency rules between variables and GUI events can be revealed by applying these methods to program states and state transitions. Given dependencies can be used to find out which variables have values that stand out against revealed rules.

In the context of this research documenting automation component was also created [6]. It allows automatically generate different documents for information systems. At current stage of developing it can generate documents for METAS CASE-system [7].

METAS is software system that has capabilities of design and creation of information systems that can be tuned on different service conditions and user requirements. System METAS uses metadata in interpretation mode to

describe target system data domain, user interface, documentation, business processes. This allows creating and dynamically tuning up information systems with no need in source code changes. Component of automatic documentation generation uses algorithms based on presentation metadata in METAS as multilayer linked lists.

During the research work two-layer documenting component working scheme was offered and implemented. This structure is shown on fig. 1.

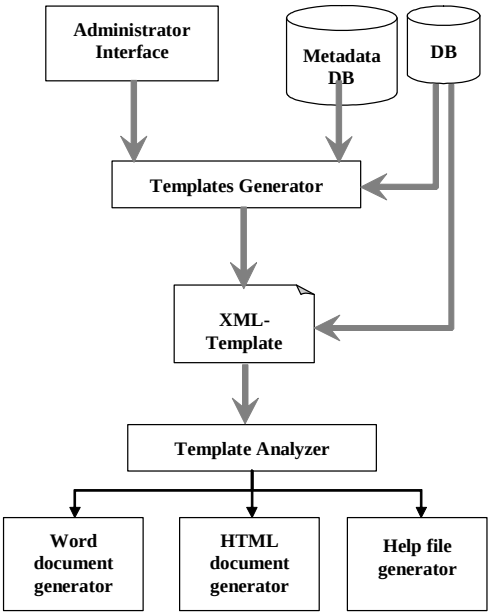

Fig. 1. Common working diagram for component of documentation generation

Implemented working scheme lets the documentation developer setup structure of target document. Document structure parameters are passed as input data into so-called Template Generator. It creates universal view that holds all documentation data from information system. Universal view has format of XML-document. Using XML allows to storage the document in presentation-independent manner. In other words universal view can be converted to user-well-known presentation at any time. For example it can be converted to Microsoft Word document, HTML page or help file.

Documentation developer must have ability to define document structure before generation, namely: ability to construct different hierarchies from documentation elements (chapters), ability to add or delete documentation elements. Special administrator interface was created to allow developer change the document structure.

This interface presents document hierarchy as tree, which can be created using visual interface and textual description by writing tags. Textual description can be synchronized with visual tree.

Administrator interface includes syntax and semantic error checking in document structure (unexpected combination of documentation elements). Semantic errors checking is needed because correct document structure may have limited number of nodes combination.

Administrator interface takes document structure information and transfers of data to XML-template generator. The main task of XML-template generator is creating XML-template, which contains information system description corresponding to document structure given by administrator interface. Template generator goes throw system metadata lists in order written in document structure. Each node in XML-template presents information from one information system object.

Template generator also contains algorithm of searching paths that lead to documenting node in recursive tree. This task is needed because METAS CASE-system has the ability to tune tree of objects (object explorer tree) at main form of created information system. This tree allows users to have easy access to necessary objects of information system. Thus it may be useful to try to describe path to each node in that tree, show the way to find each documenting object in information system's tree.

Template generator can insert images of visual elements (e. g. forms, pages, controls) to generated document by using function of making photo. Visual control image is saved in separate file and then reference to that file is inserted into template.

Next, XML-template analyzer parses existing template file and transfers information system description to end documents generators. Each end document generator transforms given data to target document format (Word, HTML and etc). Document generator must implement fixed interface to be able to receive data from template analyzer. Analyzer uses SAX method of event-based XML- document parsing.

Each node in XML-template describes one object. In addition to node attributes that contain object data each node has special attribute ID which contains index of corresponding object in table of database (fig. 2).

Keeping ID attribute per object allows quickly find original record in data base (DB) during template analysis. This function allows verifying if documented object from template still exists in DB. If object from DB has different data than one from template it may be caused by two situations: table reindexing procedure was executed; manually data changing in template was made. In each situation template analyzer will ask user which of two objects can be taken for documenting.

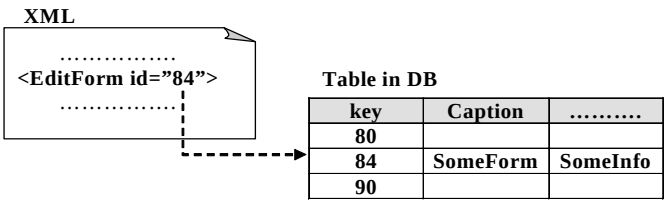

Fig. 2. ID attribute and table key connection

End (target) document generator for Microsoft Word was implemented to demonstrate ability of generating documentation for offered approach. The generator interacts with Word by using OLE. Word document generator takes data strictly from template analyzer.

Implemented documentation component allows:

- to present information system data in universal format (XML);
- to separate processes of extracting information from information system (IS) and documentation generation;
- to convert universal data presentation to any format of document;
- to make documents with different structure;
- to support documentation and database integrity.

Example of offered approach working corresponding to scheme described above is shown on fig. 3.

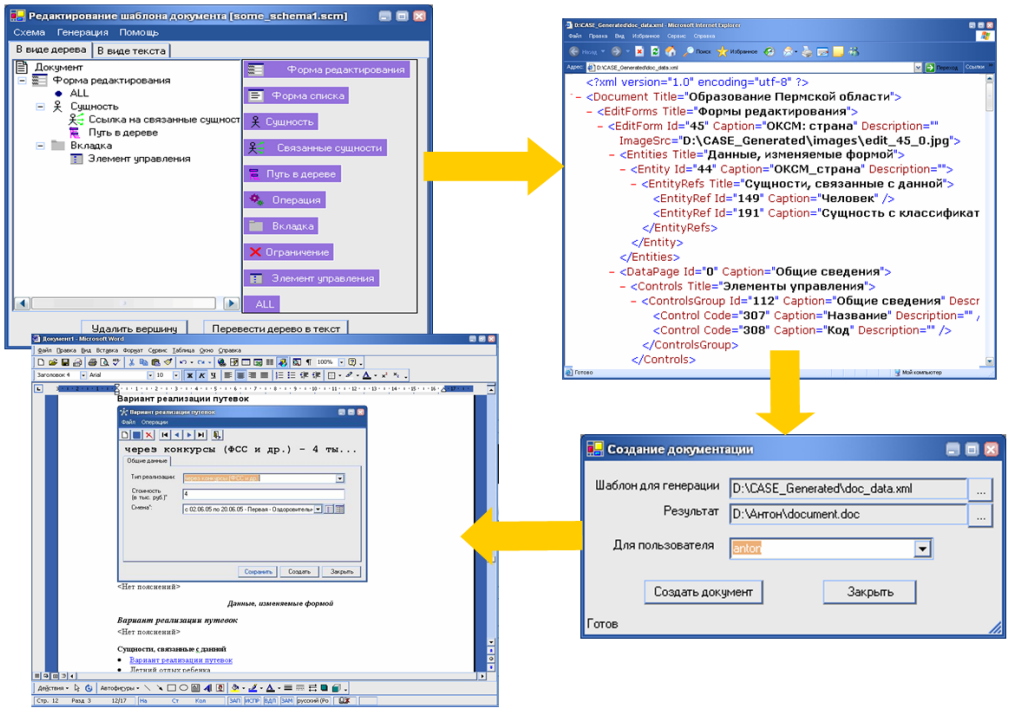

Fig. 3. Example of offered approach working scheme

Process of documentation generation described above consists of these steps:

- document structure description,
- template generation,
- end document generation parameters setting up,
- Word document creation.

Implemented documentation generation component allows creation of different XML-templates containing IS data with required structure. So the component gives to developers the ability of quick generation of documents having different structure and content.

At present time ability of dynamic grammars applying in template generator is researching. Metadata processing algorithm is changed depending on meaning of links between metadata elements. During the research work task of presentation of rules for metadata elements combinations processing was posed. This task requires giving to developer the ability to change this rules. These rules can be presented as information about links between metadata elements (second-level metadata or metametadata). This approach allows implementing documenting component as a separate module which would integrate with any information system based on linked lists. It also offers more opportunities for making documentation structure.

Mathematical model describing dynamic grammars applying in documenting algorithm was developed. Taken decisions were proved formally.

Conclusion

Proposed testing automation method allows test cases generation and execution at any stage of program under testing creation, because of opportunity to choose controlled program variables. Besides regression testing is available if testing system will save previous tests.

Documenting component structure provides further enhancement. During the research work some new ideas about working scheme improvement appeared.

Implemented component can be used for automatic documentation creation in different information systems and also for generating document templates which further can be elaborated to end document by documentation developer.

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ARCHITECTURE AND IMPLEMENTATION OF REPORTING MEANS IN ADAPTIVE DYNAMICALLY EXTENDED INFORMATION SYSTEMS

Vyacheslav Lanin

Abstract: This article describes architecture and implementation of subsystem intended for working with queries and reports in adaptive dynamically extended information systems able to dynamically extending. The main features of developed approach are application universality, user orientation and opportunity to integrate with external information systems. Software implementation is based on multilevel metadata approach.

Keywords: CASE-technology, adaptive information system, electronic document, query builder, report generation.

ACM Classification Keywords: D.2 Software Engineering: D.2.2 Design Tools and Techniques – Computer-aided software engineering (CASE); H.2: Database Management: H.2.3 Languages – Report writers; H.3.3 Information Search and Retrieval – Query formulation.

Introduction

Currently term «business intelligence» is understood as tools for data analysis, reports and queries building. These tools aid users to process great volume of data for extracting and producing desired information. Fetching of data processing results (contained in database or data warehouse) is one of the main functions of each information system. Information is entered and collected for further processing (OLTP systems), analysis, forecast and decision support (OLAP and DSS). Information contained in database must be not only processed but also visualized, presented in different document formats according to users informational needs.

Thus, when any information system is developed, tasks of creating means for query building, report design and generation appear. If it is possible, this means should not require user programming skills, vice versa it must be intended for users, who able to work in office program environment. «Business intelligence» means are practically components of most information system; its implementation determines whole system effectiveness.

Requirements to reporting subsystem of CASE-system METAS

Development of information systems, which allow

- capability of dynamical customization according to varying environment and user needs changing,
- functionality extending during system using,

requires special tools.

The CASE-technology METAS (METAdata System) is a base for creating adaptive information systems, which are managed by metadata [1]. This technology is intended for lowering labour-intensiveness of enterprise information systems development and increase its flexibility, scalability, adaptability immediately at runtime. The essential difference between under consideration CASE-system and any other CASE-systems which generate executive code using data domain specification is that our system uses this specification in run-time. In other words, metadata describes data and functions of information system built on METAS technology. It provides flexible application customization, conversion of data objects structure in system maintenance time; this capability may be used as a base of creation intelligent system that would adapts for user needs. METAS technology is intended for development of open distributed application. Therefore reporting subsystem must take into account these technology features [2].

Reporting subsystem must implement following functions:

- creation of queries to database in terms of data domain by user;
- reports generation on bases of prepared by user templates;
- report templates and queries passing between hosts of distributed system;
- integration with external systems.

Consider listed above requirements in detail taking into account METAS technology features and probable using of information system built on this CASE- technology.

A core requirement to reporting subsystem is providing a user interface that aids nonprogrammer users to prepare reports and queries in usual data domain terms. The reports can be quite complicated; it can include additional data processing, analysis and visualization. The system must provide for extension facility (creation of new reports and queries). Furthermore user does not have to use any program language or SQL queries, just the reverse; user must work in well-known environment. Necessary condition of desired requirement implementation is using of advanced metadata. These metadata have already presented in information system built on METAS technology; it describes data domain of a system. So, either data domain and created by user reports and queries can be described in the same terms.

It is necessary system to have means for storage of created queries and report templates (reporting objects); this means must allow to reuse, edit and stored queries and report templates use as a source for new queries. This requirement leads to necessity to include *reporting model* in the metadata structure, this model describes queries and report templates. Means for advanced data exchange between different subsystems are needed. Hence reporting objects and metadata descried it have to be simply portable.

Query building needs writing complex conditions and expressions. Usually so called “expression builder” is applied for this purpose; this component allows to build expression from core construction and ensure syntactical checking of expression. Build-in formula language is demanded for expression builder power increase.

Tools for report item positioning must be provided for user, when he creates new report. Requirement to accuracy of report item positioning may be enough critical, especially when reports are intended for external reporting or automation processing.

Means for integration with external software are needed for document view and edit direct from system. Especially close integration must be organized with e-mail systems as one of the main means of document exchange.

One more requirement is opportunity of using different database system.

Essential features of suggested approach are common engine of document processing from different sources, automation of data exchange processes with different information system, providing capability of texts and documents import from different format files and database. It is necessary to support opportunity of using OLAP и Data Mining for data analysis.

Implementation of Reporting subsystem of CASE-system METAS

As stated above, one of the main requirements to reporting subsystem is capability to create reports and queries by nonprogrammer user. Such requirement can be fulfilled only due to including additional semantic layer; a base of this layer can be metadata already presented in METAS system. Semantic layer allows users to operate with data in terms used in specific data domain, abstracts his mind from physical normalized data table structure. In suggested approach reporting subsystem consists of two components, such as “Query Builder” and “Report Generator”.

A user interface of query builder bases on similar Microsoft Access tool well-known to many skilled users. According to suggested approach a user chooses entities involved into a query and necessary relations between them. After then the user selects needed entity attributes and enters other parameters that affects to result sorting and grouping. As a result taking into account user conditions and metadata interpretation query builder generates SQL-query to information system database automatically.

Report generator is a special tool for report developing. Microsoft Word documents and Excel workbooks may be used as report templates. Also Report generator has a function of reports and queries import/export for exchanging with other hosts of a distributed information system.

According to suggested approach user action order on development new report is following:

1) preparation of necessary queries with “Query Builder”;
2) preparation of document template (including into template static information such as appearance items, formulas, diagram and etc.) and its markup (including into template information about ranges, where query execution result will be inserted when document based on template will be generated);
3) linking of queries and corresponding document range, that will be used for data paste;

4) saving created template in metadata base for hereafter using.

Suggested approach has some important advantages. First of all, programming and writing SQL-query is not needed for development a new report. Second, if analytic facility of query is not enough additional data processing can be performed in Microsoft Excel workbook. Third, report template is a part of metadata because template is kept in metadata base; it allows replicating template with its queries between hosts of information system therefore software update is not needed in contrast to traditional system.

A report generation sequence is following:

1) report template is extracted from metadata base and new documents are created on its base;
2) all queries are run linked with templates;
3) query execution results are inserted into report ranges; if it is necessary additional data processing run;
4) created report is saved into database as a document, it can be printed or passed by network;

Due to the fact that METAS implements electronic document storage in the database created report becomes a part of information system data. Therefore analysis of different time period documents allow creating new combined report.

Approach to development reporting means described above can be implemented in the system which has architecture shown on Figure 1.

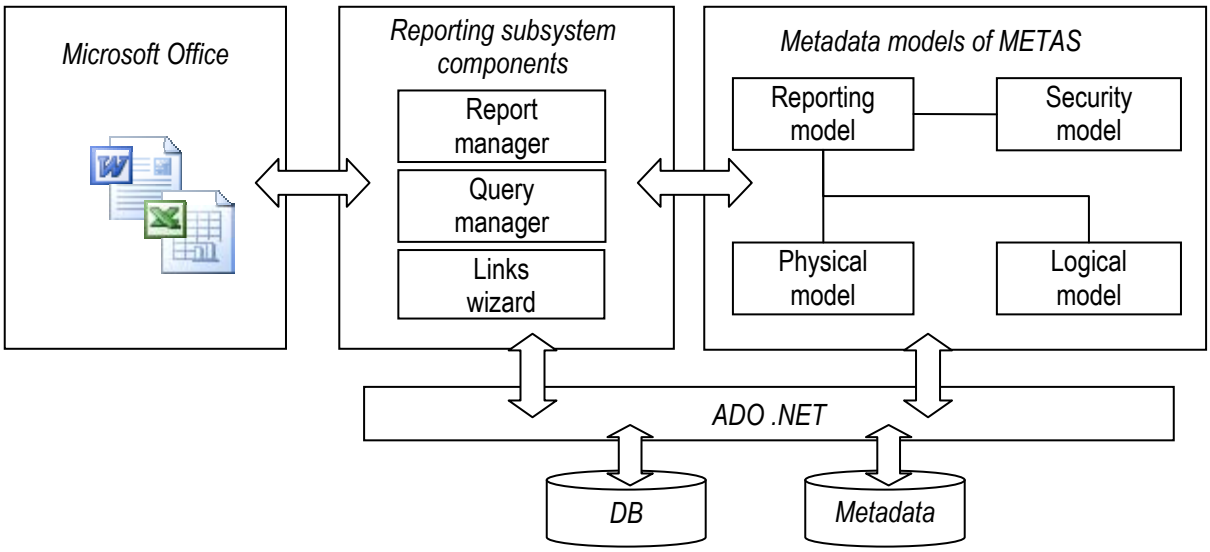

Figure.1. Reporting subsystem architecture

Developed reporting model includes two sub models: query model and report model. This sub models are entirely integrated to common metadata conception of METAS technology, it relies on functionality of physical, logical and security models. Program interface of reporting model is used for:

- execution, addition, deletion and editing query in information system database; this query is formed in terms of logical model of metadata kernel i.e. in terms of entities and its attributes;
- report templates management: generation of report on base of certain template, addition, deletion and editing of report template.

The query model is intended for storage information about queries created by user, editing already existing queries, and its export/import capability, while report model holds information about available reports. A feature of report model is direct storage of report template in metadata.

Program component “Query manager” is used for query handling by user; it is interface for query model. “Report manager” is user interface for report model. Component “Link wizard” is intended for binding report template ranges to queries with aid of graphical interface.

An algorithm of query generation

As described above query created by user is storaged in reporting model of METAS metadata; while data of information system holds in relational database. Hence task of query compilation from object model to SQL appears.

A user forms his query in terms of entities; he expresses constraint and needed fields with aid of expression where logical model terms are used (entities, attributes, etc.). Because of result of generation query process must be SQL query to database of information system, it is obvious name of entities and attributes can not be used. So, compilation from terms of logical model to database tables and fields is necessary. But solution of this task is very complicated; powerful expression analyzer must be created or user must be limited in possibility to build complex expression.

An original solution is suggested, it do not limit user in expression complexity and do not demand labor-consuming programming. Sources of data will not be database tables but preliminarily adduced to 1NF entity view. METAS logical model already has means for generating such views. Because of this approach same view of data sources and expressions are taken.

Taking into account query model and operation features of METAS kernel framework it is necessary to present query to following view.

SELECT query_fields
FROM ((query_for_Entity1) Alias_for_ Entity1
INNER|*LEFT*|*RIGHT JOIN* (query_for_ Entity2) Alias_for_Entity2
    ON join_condition_Entity1_and_Entity2, …
INNER|*LEFT*|*RIGHT JOIN* (query_for_EntityN) Alias_for_EntityN
    ON join_condition_EntityN_and_EntityM),
        join_entity_tables_M:M, (…) Alias_for_Entity(N+1),…,
        (…)Alias_for_Entity(N+n),
WHERE join_entity_conditions_M:M, user_conditions
GROUP BY group_by_expression
ORDER BY order_expression [ASC | DESC]

The key algorithm stages are following.

1. Creating a list of fields which will be output as a result of query execution.
2. Separation of entity set used in query to three subset:
   - linked with aid “left join”, “right join” or “inner join” (*JoinLinked*);
   - linked with relation M:M and not included in first subset (*MultiLinked*);
   - other entities used in query (*NotLinked*).
3. Call to logical model for SQL query for each used entity (logical model generate query which retrieves table entity view in 1NF).
4. Generation of “FROM” query part:
   - merge of queries obtained on step 3 of this algorithm for each entity from set *JoinLinked* with aid of indicated join type (LEFT JOIN, RIGHT JOIN, INNER JOIN), assignment of aliases to query results;
   - enumeration of queries for entities from set *MultiLinked*, for each entity assignments alias and auxiliary tables organized relation M:M;
   - enumeration of queries for entities from set *NotLinked*, assignment of aliases to query results.
5. Generation of “WHERE” query part:
   - addition for each entity in *MultiLinked* relation condition;
   - addition user condition to entity attributes.
6. Generation of “ORDER BY” query part by merge ordering items.
7. Generation of “GROUP BY” query part by merge grouping items.

Described sequence of actions leads to SQL query generation in terms of tables and fields of information system database. This query will be performing directly to database without call to metadata models.

It is obvious generated query is not optimal by its structure, because inconsistency requirements were prompted. However taking into account all modern database systems have internal query optimization means and speed of system response is not critical important suggested approach suits main requirements. It is important to notice source of optimization consist in logical model. Logical model retrieves 1NF as a response of query included all attributes same of them can be not obligatory for query execution. Thus text query size and execution speed can be decreased by addition special functionality to logic model.

Conclusion

Suggested approach to development of reporting subsystem of CASE-system METAS allows to create flexible, user-oriented systems for reports and queries management. Using metadata allows avoiding writing queries on SQL when user needs to create new query. Developed reporting subsystem is an important part of integrated approach to electronic document management in CASE-system METAS.

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AN APPROACH TO REPRESENTING THE PROCESS OF INFORMATION BUSINESS MODELING

Nadezhda Filipova, Filcho Filipov

Abstract: The compact and visualized documenting of information business modeling is a major prerequisite for comprehending its basic concepts, as well as for its effective application and improvement. The documenting of this process is related to its modeling. Thus, the process of information business modeling can be represented by its own tools. Being based on this thesis, the authors suggest an approach to representing the process of information business modeling. A profile for its documenting has been developed for the purpose.

Keywords: business modeling, SPEM, UML profile

ACM Classification Keywords: I.6.5 Model Development - Modeling methodologies

Introduction

Information business modeling (infBM) aims at visual representation of the business processes of the target organization by means of methods for information system development [Filipova, 2003]. This is a methodology for analysis and reengineering of organizations, as well as for developing adequate integrated computer information systems (CIS). Hence, infBM is a common business process, through which one could represent business processes, performed in organizations, including these for analysis and design, CIS development methodology, etc. This means that infBM is a process for modeling and representing other processes, i.e. this is a metaprocess. This basic feature of infBM emphasizes its importance, and the necessity to understand its components, tools and mechanisms.

According to us, the metamodel of infBM can be the basis to represent the process of its realization. Our researches in the field of the system development metaprocess, and our experience in object-oriented modeling make us assume that the infBM metamodel can be defined, using the SPEM metamodel and the UML profile mechanism.

In this context, our goal is to suggest an approach to representing the infBM process in a compact and visual way. For the purpose, a profile for the process of infBM will be defined on the first place, and then it will be transformed into a profile for its documenting.

I. A framework for representing the process of infBM

Information business modeling is a process that can be represented by the object-oriented approach. According to the modern concepts, a four-layer architecture can be used for object-oriented modeling of real processes and phenomena. Its layers are in hierarchical order, and each one can be represented through the concepts of the upper one (Table 1). We must note, that this is an architecture for representing both the process and the product or the system, created in its application.

Table 1. A four-layer architecture for object-oriented modeling

Layer	Name	Contents
M3	Metametamodel of the process	MOF(Meta Object Facility) – integrates methods and processes into a common framework. The metamodels in MOF are represented by a subset of the UML
M2	Metamodel of the process[1]	UML, SPEM, basic concepts / metamodel of infBM
M1	Model of the process	A concrete instance of the CIS development methodology – e.g. IBM RUP [Kruchten, 2003; Rational 2003], OPEN [Henderson-Sellers, 2000], MSF (Microsoft Solution Framework) [Duffy, 2003], XP, infBM, etc.
M0	Executable process	A real process for implementing a project

The dotted line in Table 1 shows the object of our research, namely layers M2 and M1 of the four-layer architecture.

The metamodel of the infBM process is a subset of SPEM [SPEM, 2005], on one side, and its specialization – on the other. The product at a metamodel level is represented by means of UML. The product of infBM however is specific, and in order UML to be applied adequately, the latter must also be specialized. The method specialization at the M2 layer may be accomplished through the UML profile[2] mechanism.

Therefore, the metamodel of the process of infBM can be defined as a specialization of the SPEM metamodel summarized in *a profile for the process of infBM*. Likewise, the UML possibilities applied in infBM can be summarized in *a profile for infBM*. Thus the M2 layer of the architecture is divided into two sublayers: a layer of the metamodel (M2.1), and a layer of the profiles (M2.2). M2.1 comprises the metamodels of UML and SPEM, whilst M2.2 includes the profile for infBM and the profile for the process of infBM. These two profiles exactly outline the framework for infBM representation. This framework is used to describe the model of the process of infBM at the M.1 layer of the architecture for object-oriented modelng. Aimed at the more compact and visual representing of infBM, we will use just a part of the profile for the process of its implementation, encapsulated into a profile for its documenting.

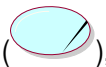
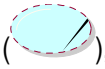
In order to document infBM on the basis of the framework defined, it is necessary to explore in details the two profiles, mentioned above, namely the profile for infBM and the profile for the process of infBM.

[1] This layer is also called a method layer

[2] The profile is defined as “lightweight extensibility mechanism”, consisting of stereotypes, tagged values, and constraints

II. Components of the profile for infBM

The profile for infBM is discussed in [Filipova, 2003; Kruchten, 2003; Rational 2003]. Its components are classified into three groups, as follows: model elements, models, diagrams. The information business models are comprised of model elements, and are represented as various diagrams.

The *model elements* include: Business use case (), Business actor (), Scope (), Business goal (), Business worker (), Business use case realization (), Business entity (), Business system (), Business event (), Business rule (). They are specializations of corresponding UML model elements.

Three major *models* are created in infBM:

1) Business use case model (BUCM) – this model reflects the business goals and intended functions of the organization, i.e it answers the question "What is done". The model is used to define the roles of the organization, and the products delivered. It represents the work of the organization as a set of business use cases, i.e. business processes.
2) Business analysis model (BAM) – represents the internal aspects (i.e the realization) of business use cases by modeling the interaction between business workers and business entities.
3) Object business model (OBM) – this is a partial BAM, including just business entities, but not the responsibilities of business workers. This model reflects the static aspects of the processes explored.

The static and dynamic aspects of information business models are visualized by UML diagrams, which are used in a specific way. They are summarized in Table 2.

Table 2. Diagrams of infBM at model levels

Model	Diagrams	
	Static	Dynamic
BUCM	- Business use case diagram	- Activity diagram
BAM	- Business class diagram	- Activity diagram - Business sequence diagram - Business communication (collaboration) diagram - State machine diagram
OBM	- Business entity diagram	

III. Defining the profile for the process of infBM

The initial prerequisites for defining the profile for the process of infBM follow:

the first, infBM is a business process;

the second, this profile is a subset of the SPEM profile, and interprets its components in a specific way;

the third, this profile uses as artifacts the components of the profile for infBM.

Our first conclusion, derived from the first prerequisite, is that the process can be represented by means of the profile for infBM. This is not a good decision however, as there will be overlapping between the representation of the process of infBM, on the one hand, and the representation of its product – on the other. Moreover, this can produce confusion in infBM process documenting. The stated problem was confirmed by our preliminary experiments on modeling the infBM process. Thus, it is necessary to define a specialized profile for representing the process of infBM.

Our second conclusion (resulting from the first prerequisite), which is also our thesis, is that there is a direct connection between the profile for infBM and the profile for the process of infBM. Therefore, we should find the

correspondence between their components. And the second prerequisite prompts that these components are inherited from the SPEM profile.

We will concern the consequences of the third prerequisite when discussing the profile for infBM documenting.

The initial prerequisites for defining the profile for the infBM process direct our strategy, i.e. we are going to seek semantic equivalence between the components of the infBM profile, on the one hand, and these of the SPEM profile, on the other. Furthermore, this comparison will be accomplished at levels of abstraction, i.e. models.

The major components of the SPEM profile are: Goal (), Workflow / Workflow details (), Phase / Iteration (), Artifact (), Process package / Discipline (), Process / Life cycle (), Role (), Activity ().

Following our strategy for defining the profile for the process of infBM, we must achieve complete equivalence between the components of the profiles, that we compare, for the first of the models, namely the Business use case model. We establish that there is neither Scope, nor Business actor in the SPEM profile. Our answer to this problem is:

- first, introduce a Scope component in the profile for the process of infBM with its meaning and icon, inherited from the infBM profile;
- second, in order to introduce a Business actor component however it is necessary to analyze its semantic. The business actor is a *user* of the products of the process of infBM. Besides, he is an external participant in this process, assisting in its implementation. Therefore, the Business actor is a user of the process, and a kind of a role with limited responsibilities. That's why we introduce a new stereotype, named Process user (), in the profile for the infBM process.

Unlike the Business use case model, we will seek just partial equivalence of the components of the Business analysis model and the Object business model. We find out difference in several components at BAM level, and to be precise these are: Business use case realization, Business event, Business rule, Activity.

The Business use case realization is a collaboration[3], i.e. it groups a set of dynamic and static diagrams, reflecting structure and behavior of a business use case. In this case the collaboration shows how a certain elementary process (a subprocess) of the infBM process is implemented through the interaction of activities, roles and artifacts, i.e. the workflow details are described. That's why we introduce a new stereotype in the profile for the process of infBM, which is similar to the Business use case realization - Workflow realization ().

The documenting experience, gathered in some methodologies, e.g. IBM RUP, proves that components such as Business event and Business rule are rarely used. Hence we will not look for their equivalences, and they will not be used in the profile for the infBM process.

We must point that the Activity component of the

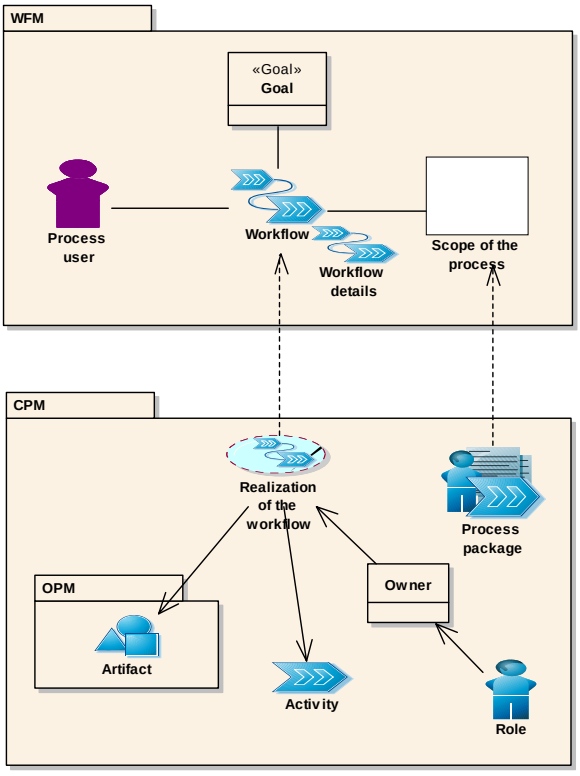


Fig. 1. Models and components of the profile for the process of infBM

[3] this is a standard UML component to implement behavior

profile for the process of infBM is an operation of the Business worker in the infBM profile.

The models in the profile for the process of infBM acquire different manifestations, which is a result of the semantic of their components. Thus, the workflow is a basic component of the Business use case model, which makes us name it Workflow model (WFM). Its static aspects are represented by Workflow diagram (analogous to Business use case diagram – Table 2), and its dynamic aspects are represented by Activity diagram. Concerning similar considerations, the Business analysis model is named Conceptual process model (CPM), and the Object business model – Object process model (OPM).

After these comments and elaborations, we can represent the components of the profile for the infBM process, and the relatios among them (Fig.1).

IV. Transforming the profile for the process of infBM into a profile for its documenting

Regarding the concepts of infBM, we assume it is adequate to build up a Business use case model, i.e. a Workflow model, in order to present a process which is both highly abstract and of wide scope, on the one side, and purposeful and easy to be understood, on the other. Hence, the profile for documenting the infBM process must encompass all the components of the WFM.

According to us, it is necessary to use the product model, represented by the infBM profile, in order to achieve greater purposefulness when modeling the workflows in infBM. This means that the components of the infBM profile are artifacts of the infBM process, and that only a part of the Conceptual process model will be used. The roles and activities of the infBM process will be used unstructurally, i.e. the relations among them are not going to be represented.

The profile for documenting the infBM process includes also the models and diagrams used. They are encapsulated into a package, named infBM models and diagrams.

The profile for documenting, we have defined, is depicted on fig.2. We must point again that the Conceptual process model of infBM has a wider scope. The profile for documenting however includes just a part of the Object process model, namely the packages Profile for infBM and infBM models and diagrams, and the Role and Activity components.

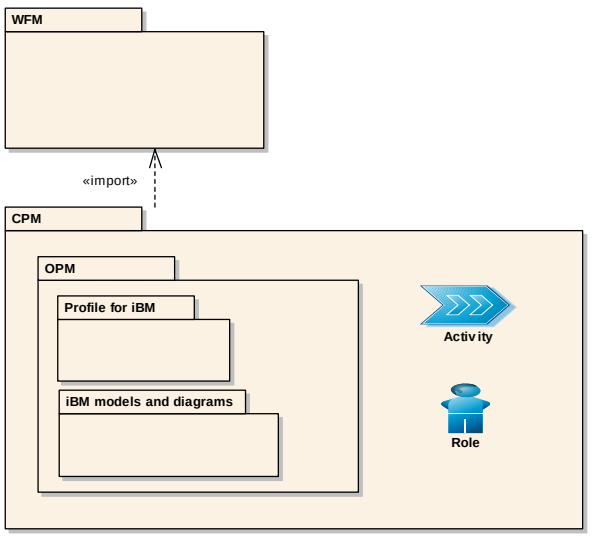
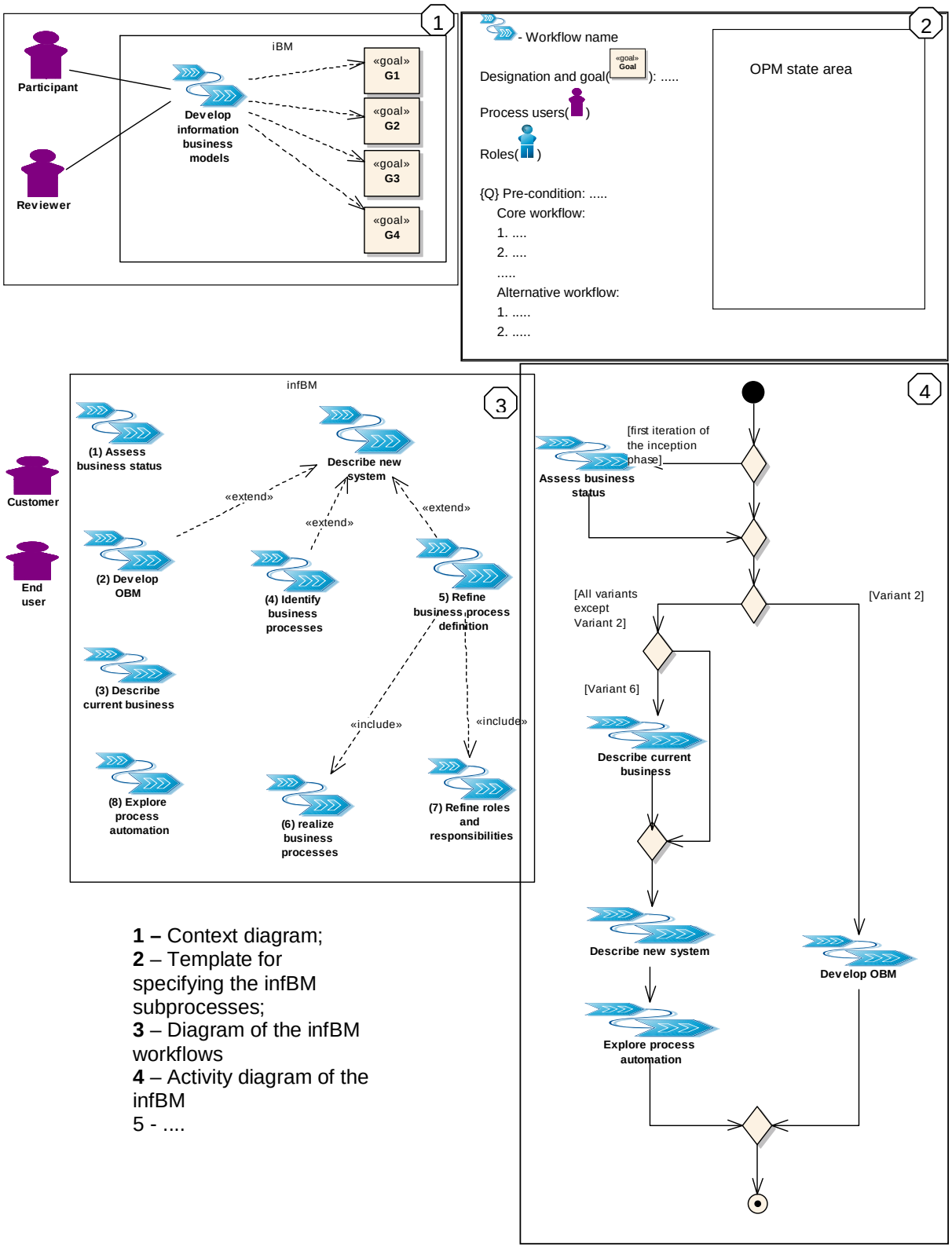


Fig.2. Profile for the documenting the process of infBM

Using the profile for documenting defined, we have made some experiments to model the process of infBM, that are based on the Business modeling workflow of IBM RUP. On the first place, we have developed a context diagram of infBM, which defines its goals and users, and decomposition diagrams, that identify its subprocesses. On the basis of a template, defined by us, the infBM subprocesses have been documented, and to be precise - their designation and goal, users and roles, pre-conditions and post-conditions, core and alternative workflows have been described. This background gave us the possibility to identify the relations among the infBM subprocesses, which is very important in order to build up its workflow diagram. We must point that a new subprocess, named Describe new system, is added in it to integrate several other subprocesses. Besides, for the purpose of not overloading the diagram, the relations among the process users (Customer and End user) and the subprocesses are not represented. The workflow diagram however does not represent the logic and the succession of the infBM process. The activity diagram with its tools that represent forking, conditions, transitions, etc., fits better this purpose.

Our suggestions for some of the diagrams for the infBM documenting are on fig. 3.



1 – Context diagram;
2 – Template for specifying the infBM subprocesses;
3 – Diagram of the infBM workflows
4 – Activity diagram of the infBM
5 - ....

Fig. 3. Diagrams and templates in documenting the infBM process

Conclusion

We will summarize the steps fulfilled in defining the profile for documenting the infBM process. On the first place, we have identified the components of the framework for representing the infBM process, i.e. the profile for infBM, and the profile for the process of infBM. Then the profile for the process of infBM has been defined, which was an important target of ours. This profile emerged on the basis of the SPEM profile, and was driven by our thesis for semantic correspondence between the profile for the product and the profile for the process of infBM. Afterwards, the profile for the infBM process has been transformed into a profile for its documenting, regarding the requirements to the model of the infBM process. Using this profile, we have made some experiments to represent the process of infBM. More precisely, we have built up the infBM workflow model and its subprocesses have been specified by the template defined for the purpose.

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DEVELOPMENT OF DATABASE FOR DISTRIBUTED INFORMATION MEASUREMENT AND CONTROL SYSTEM

Sergey Kiprushkin, Sergey Kurskov, Vadim Semin

Abstract: The purpose of this work is the development of database of the distributed information measurement and control system that implements methods of optical spectroscopy for plasma physics research and atomic collisions and provides remote access to information and hardware resources within the Intranet/Internet networks. The database is based on database management system Oracle9i. Client software was realized in Java language. The software was developed using Model View Controller architecture, which separates application data from graphical presentation components and input processing logic. The following graphical presentations were implemented: measurement of radiation spectra of beam and plasma objects, excitation function for non-elastic collisions of heavy particles and analysis of data acquired in preceding experiments. The graphical clients have the following functionality of the interaction with the database: browsing information on experiments of a certain type, searching for data with various criteria, and inserting the information about preceding experiments.

Keywords: Database of distributed information measurement and control system, database management system Oracle9i, distance learning.

ACM Classification Keywords: H.2.8 Database management: Database Applications

Introduction

Automatization of scientific research and use of software-driven modular electronics significantly simplify experimental work making it less time-consuming and more accurate. However, a database of an experiment appears to be a non-negotiable condition for data logging, ordered storage and user-friendly maintenance.

The aim of this work was to develop a database for distributed information measurement and control system that would implement methods of optical spectroscopy in atomic collisions and plasma physics as well as provide a remote access to its resources across the Intranet/Internet.

Distributed Information Measurement and Control System

A distinct feature of the distributed information measurement and control system is that it allows combining different device interfaces along with their control computers into uniform network functioning on the basis of TCP/IP.

The distributed system is built as a centralized system [Gavrilov et al., 2003] – [Kiprushkin et al., 2006]. The structure scheme is presented in Figure 1.

The system is comprised of the following parts: the communication (central) server; the equipment servers (CAMAC server, GPIB server, the server of Intel MCS-196 microcontrollers, Ethernet devices server and the server of access at GDS-840C digital oscilloscope et al.); the client programs fulfilling the collection, accumulation and processing of information and experiment control; the universal protocol connecting the communication server with the equipment servers; and the extended protocol connecting the communication server with the client programs.

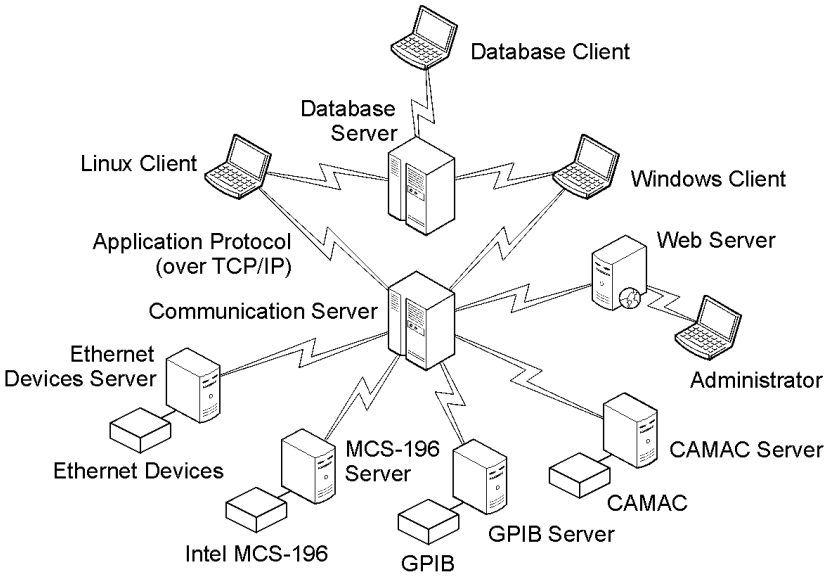

Figure 1. The scheme of the distributed information measurement and control system

The distributed information measurement and control system is based on the modular approach implemented both in the structure and in the software. Clients and equipment servers are built into the system according to the unified rules and interact on a unified protocol by the principles of open systems. Note that an open system is a system that implements open specifications or standards for interfaces, services and formats in order to provide software portability with minimal changes in a wide range of systems (mobility) as well as interaction with other applications on local or remote systems (interoperability) and users (user mobility) [James et al., 1994]. In particular, distributed systems are based on OSE/RM model that describes systems by client/server architecture.

The distributed system was written in Java language – an object-oriented programming language, its platform-independent programs run similarly on diverse hardware with Java virtual machine. Along with this, web-technologies were widely used, too.

Administration of the distributed system is based on server-side Java servlet. Using the servlet started up on the Web-server, a system administrator logins to the communication server as a privileged user. S/he monitors resources of the distributed system, may deallocate resources and disconnect clients. The system administrator grants clients' access rights for the equipment servers, ensures unique client and server identifiers, and maintains public-key database of all parts of interconnection.

Note that a communication server of the distributed information measurement and control system is only a moderator between the equipment servers and the client programs that collect, accumulate and process data. That is, its main function is to maintain multiuser mode and correct allocation of resources among clients, to monitor and to protect the system. Therefore, there is a direct client program-server interaction bypassing the central server. More than that, the latter has no information on the type of the current experiment.

Database of Distributed System

Currently, the most popular database management systems (DBMS) are Borland Interbase, Oracle, MS SQL Server, MS Access and MySQL. Chosen DBMS Oracle9i, namely Intel Pentium 4 compatible Oracle 9.2, perfectly meets such crucial criteria as protection of data integrity, administering capabilities, crossplatformness, guaranteed data storage and recovery, capability to work with large amounts of data, and Java language support [http://www.oracle.com; http://asktom.oracle.com].

Practically, Oracle DMBS works as a broker between the database and its users. Oracle server is a high-speed multithreaded multiuser SQL server. It can serve high-load critical production systems as well as mass software. The server authorizes clients' access to the database, processes queries and sends information back to clients, or informs them if an accidental error occurs.

When a client sends the data, DBMS verifies if this client is authorized to write the data. If authorization is valid, the server registers it in the database and sends a confirmation back to the client. If access is denied or an error occurs in data write (or transfer), the client receives a notification. It is important that only the core has an access to all data in the database, client applications never write any data directly in the database.

The software for database clients was developed using Model View Controller Architecture (MVS) that separates application data of the model from graphical presentation components and input processing logic (controller).

The following graphical presentations were implemented: measurement of radiation spectra of beam and plasma objects, excitation function for non-elastic collisions of heavy particles and analysis of data obtained in proceeding experiments. Developed client programs manage the course of the experiment by interacting with the equipment servers through the communication server and transferring acquired data to the database. The graphical clients have the following functionality of the interaction with the database: browsing information on experiments of a certain type, searching for data with various criteria, and inserting the information on proceeding experiments.

The developed database stores outputs of the following experiments: measuring optical spectra of plasma objects, excitation spectra of atomic-atomic and ionic-atomic collisions, cross-sections of spectral line excitation with fixed collision energy along with dependence of excitation cross-sections on energy of colliding particles. The data is stored in corresponding tables with Java access. Java Database Connectivity (JDBC) API supports interaction with DBMS Oracle9i. Tables are created using Java utility.

Tables are bound by means of certain relations. This provides the possibility to combine them in a single query. The most frequently used tables are as follows: a table of users and their rights, a table of initial experimental parameters, tables for each type of an experiment where experimental data is logged.

In the distributed system, each part of net intercommunication can login to the database with a unique username and a password. The system administrator registers DBMS users and grants or revokes access at four privilege levels: global, database, table, and column.

The software was implemented using J2SE Development Kit v5.0 and development environment NetBeans 4.0 [http://java.sun.com]. A well-designed interface ensures effortless implementation of graphical applications with NetBeans 4.0 tools. A significant advantage of NetBeans is that this environment is produced with the components that allow working with Oracle DBMS using its own API, which provides high-speed data traffic.

Implemented software was assembled into a software complex for Windows operating system with the help of Excelsior JET 3.7 packet. This packet is user-friendly – it automatically installs JRE 1.5, JDBC-Think driver, creates shortcuts on the desktop and in the Programs menu.

Conclusion

The implemented database contributed to the organization of data storage, provided easy and quick access to experimental results, which simplified data processing and analysis of obtained results. The data is available online to researchers from all over the world and can be used as a tool in distance education.

It is necessary to point out that the developed database of distributed information measurement and control system is used for the beam and plasma object analysis with the help of optical spectroscopy methods. In particular, the researches on excitation processes of atomic collisions with inert gas atoms' participation are carried out with its help as well as the laboratory works with senior students of Department of Physics and Engineering of Petrozavodsk State University.

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AN APPROACH TO DESIGNING THE INTERFACE OF THE AUTOMATED DOCUMENTARY SYSTEM

Arsenij Bakanov, Vladislava Grigorova

Abstract: In the paper the procedure for calculation, designing and estimation of the ergonomics of the interface of systems of document circulation is considered. The original computation procedure and the data received during the designing of the interface of documentary system are given.

Keywords: Designing of the interface, design, ergonomics.

Introduction

The increasing complexity of the solved by the computer systems problems demands higher requirements for their productivity and speed. However for the increasing of the productivity and the operating speed of the computing systems it is not sufficient simply to extend the CPU clock, data bus width or the capacity and the quantity of HDD.

The operating speed and the productivity of the computer systems or “human-computer” systems depends not only on the computer productiveness or the processing speed (the speed of input of the information/commands) of the user but also on the clearness and completeness of the information, presented by a computer; how "clear” will be the user commands to the computer.

Let us consider the “human-computer” system on figure 1.

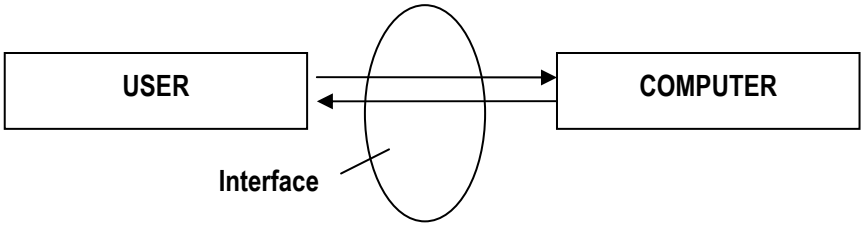

Fig. 1

The computer gives information, on the basis of which the person – the user – makes a decision and performs control action on the computer. The computer executes commands and gives the new, actual information on the basis of which the person makes new decision, etc. The productivity of the considered system will depend on how ergonomically the human computer interface is realized.

There are various techniques that allow the quantitative and qualitative estimation on the ergonomics of the interface. In the paper the problems of estimation and designing of the interface for the automated documentary system are studied.

Techniques for estimation of the interface ergonomics

The following methods are used for the interface ergonomics estimation:

1. Method of expert / subjective evaluation

The interface ergonomics estimation is carried out by a group of experts on the base of their personal operational experience. As the experts evaluate the interface in different ways on the base of their own subjective criteria then it is advisible to involve several experts (it is recommended to take three up to five experts, because too many experts increases the complexity in the analysis of the received information).

2. Testing - the comparative analysis

The users take participation in the testing. The aim of the testing is revelation of typical mistakes from the user side during working with the program interface. It is advisible to propose different variants of the interfaces in order to the user can choose the most ergonomic one.

3. Quantitative methods – multicriteria analysis

The speed of work of the user, the speed of training and the quantity of the mistakes are the basic characteristics of the ergonomics of the interface.

Traditionally the GOMS model (the model of goals, objects, methods and selection rules) [1] is used for the quantitative estimation of ergonomics of the interface. The GOMS modeling allows predicting and forecasting what amount of time will be needed by the user for performing particular operation by using the given interface model.

According to the GOMS model the time that is required for the accomplishing of some task by the system "user-computer" is a sum of all time intervals which were required for performing a sequence of the actions that correspond to the components of the given task.

The GOMS method gives good quantitative estimations for different variants of the user interfaces. In practice the developers use expanded models, such as, CPM-GOMS (critical-path GOMS method), in which additional parameters are considered.

For evaluation of ergonomics of documentary systems it is expedient to use a set of coefficients together with the GOMS model followed by multicriteria analysis.

The mentioned techniques are good enough for an estimation of already created interfaces, but it is difficult to apply them to the designing of the intefaces.

Technique of designing of the interface

Let us consider a technique for the designing of the interface on example of the automated system of Documentary Maintenance of Management (DMM). The interface of the considered automated system represents a sequence of screen forms with some fields. Part of the fields is filled by the user and another part is filled automatically.

Each field can accept a final number of values. The information of some screen form can be evaluated. We shall measure the information of the screen form as entropy reduction. That is, considering the screen form before filling (when its condition was indefinite), its entropy was $H(X_i)$. After filling all fields (the condition was completely defined), entropy becomes equal to zero. Therefore, it is possible to define the information received as a result of filling all the fields, as

$$I_X = H(X_i) - 0 \quad \text{or} \quad I_X = H(X_i).$$

All possible states X_i of the screen form with their corresponding probabilities P_i are represented on the table 1.

X_i	x_1	x_2	x_3	x_n
P_i	p_1	p_2	p_3	p_n

Table1

According to [1] the entropy is defined as

$$H(X_i) = -\sum_{i-1}^{n} p_i \log p_i,$$

where the logarithm on the basis two is used. For the considered screen form we define the following characteristics:

- the total quantity of screen forms according to [2] should not to exceed $J = 7$;
- the quantity of fields with scrolling should not exceed $K = 5$;
- the quantity of input fields (supposing input no more than five symbols) should not exceed $L = 4$;
- the quantity of input fields with help (i.e. such in which the system carries out input of a word under the two first letters) should not exceed $M = 3$;
- we shall enter into consideration some coefficient R_i describing time spent by the programmer on the development of the given element of the interface;
- to each type of a field we shall put in the conformity some coefficient t_{ij} describing time expenses of the operator for filling of the given field. Then the general time for filling of the given screen form will be:

$$T_i(J) = \sum_{j=1}^{J} t_{ij}$$

Under these conditions, for the given concrete case it is possible to formulate criterion of productivity for the interface:

$$H(X_i) \to \max$$

$$T_i(J) \to \min$$

The results of the analysis of the input fields that is made in conformity with criterion of productivity are resulted in table 2.

Type of a field	Choice from the list	Input with the help	Input without the help
Description	Before information input all three states are equiprobable, that is why [1] $H(X) = \log n$	In unknown three words we are interested in combination of five letters in twos. The number of possible equiprobable states is 10.	Combination of five letters from 32. Number of possible equiprobable states is 32^5
Numerical value	$H(X_i) = \log 3 = 1{,}584$	$H(X_i) = \log 10 = 3{,}321$	$H(X_i) = 5 \log 32 = 25$
Coefficient, describing the time spent by the programmer on the development of the given element of the interface	1	3	2
Coefficient, describing the time for filling of the field by the user	1	1,5	2

Table 2

Conclusion

According to the data from table 2 the following recommendation for the designing of the automated documentary system interface can be formulated: on the base of productivity criteria, time expenses of the user of the documentary system for filling forms and time expenses of the programmer-developer for interface creation in the considered interface it is advisible to use:

- number of fields with scrolling *K = 3*;
- quantity of input fields (allowing input no more than five symbols) *L = 2*;
- quantity of input fields with help (i.e. such in which the system carries out input of a word under the two first letters) *M = 2*;

Thus, *J = 7*, i.e. the total amount of screen form fields in accordance with [2] is equal to seven.

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THE STRATEGICAL IMPACT OF KNOWLEDGE MARKETS AND KNOWLEDGE MANAGEMENT FOR SMALL AND MEDIUM ENTERPRISES

Todorka Kovacheva

Abstract: According to the rapidly changing environment small and medium enterprises constantly need to adapt their strategies and activities. The transition from the industrial economy to knowledge-based economy results in the increasing of the volume of the available information. Therefore knowledge markets are needed and innovation centers have to be developed. An effective knowledge management system helps small and medium enterprises to overcome their disadvantages and compete with big corporations. The review of current developments in the field of knowledge markets is also made.

Keywords: knowledge, knowledge markets, knowledge management system, knowledge-based economy, information society

ACM Keywords: K.4.3 Organizational Impacts, D.0 GENERAL, H.4.3 Communications Applications

Introduction

The globalization and technological developments increase dramatically the information available for the human society. The need of ussage of automated tools for the extraction and processing of information appears. This information can be processed throught Internet and characterizes with large variety and is unstructured. Therefore the knowledge contained in it can not be extracted and used for the increasing of the effectiveness of the functioning of the contemporary enterprises.

In the continuous and rapidly changing environment with high level of competition for the small and medium enterprises is more and more difficult to survive and growth. They do not have the large amount of financial funds like big corporations. By the ussage of the knowledge hidden in the large volumes of freely available information these enterprises can receive high competitive power and successfully compete with big corporations in the virtual and real world market.

The small and medium enterprises can easy become transnational companies which operate on the global market. This is possible as a result of business virtualization, information technologies and telecommunications, Internet and etc.

To use the advantages from the changes in the global economy, small and medium enterprises have two possibilities:

1. to buy knowledge from the knowledge markets, or
2. become a knowledge centers and develop innovations.

Knowledge Markets

According to the fast development of Internet and Information and Telecommunication Technologies causes the appearance of new economy, called Internet or Knowledge Based Economy. A knowledge economy focused on the economy of the producing and management of knowledge. It is also the use of knowledge to produce economic benefits [1]. The term was suggested by Peter Drucker [2]. The Knowledge Economy is not currently absolutely established. Our society is in transition to an information society. And the industrial economy of the 20th century turns into the knowledge-based economy. It is changing the rules of business and competitiveness. The contemporary business competition is based on knowledge. It makes possible for small and starting enterprises to become global and transnational corporations operating with small investments in the world's global market.

The stages in development of the information society are well defined in [3]. The authors in [3] define the difference between information society and other levels of the human been growth by the domination of the information interests above all others. In the information society the payable information exchange and services dominate above all other market activities. As a result, the Information Market dominates over all other type of markets of the information society. The authors in [3] define the Knowledge Market as a special kind of

Information Markets. As the other markets the Knowledge Market is the organized aggregate of participants, which operates in the environment of common rules and principles [4]. The interactions between memebers of the knowledge markets are described in [5].

A real functioning global knowledge market currently does not exist. There are few attempts to develop such a market but the results are still far from the real knowledge market. Based on the analysis and review of the available scientific literature and information sources the following developments in this field are discovered:

- The theoretical basis of knowledge markets is established in [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]
- An attempt of establishing knowledge markets is made by BRINT [16, 17], The Knowledge Creating Company. It is currently the leading institution in the knowledge market. It is the world's virtual gateway to the largest pool of talented minds involved in contemporary business technology management and knowledge management research and practices across the USA and all other countries of the world.
- Other developments:
  - The World Bank [18] – Knowledge for Development Program. The Program provides policy advice on four Knowledge Economy pillars: economic and institutional regime, education, innovation, and Information and Communication Technologies (ICTs). It helps countries identify the challenges and opportunities they face in making the transition to the knowledge-based economy. The KAM consists of 81 structural and qualitative variables for 132 countries to measure their performance on the four Knowledge Economy (KE) pillars: Economic Incentive and Institutional Regime, Education, Innovation, and Information and Communication Technologies. Variables are normalized on a scale of zero to ten relative to other countries in the comparison group. The KAM also allows to derive country's overall **Knowledge Economy Index (KEI) and Knowledge Index (KI).**
  - The Kaieteur Institute For Knowledge Management [19] delops an e-Knowledge Markets Meta Portal [20].
  - In April 2006 the Work Foundation [21] announced the start of a major three-year, £1.5 million research programme into the nature of the knowledge economy - the biggest investigation of its kind anywhere in the world. The project aims to identify what the knowledge economy is, and how advanced nations can use knowledge and information to spearhead economic growth and competitiveness in the 21st century.

Knowledge Centers and Knowledge Management System

The transition from the industrial society to the information based society and the transition from the industrial economy to the knowledge-based one logically results in changes in the global business. New industries, new business relationships and new kinds of jobs will appear. To survive in such an environment small and medium enterprises need to have high adaptive capability. Such adaptivity they can receive from the knowledge about the trends and correct forecasts about the changes in the global economical, political and social development. Such knowledge can be established by effective knowledge management system.

Knowing the global business trends small and medium enterprises can become knowledge and innovation centers. Developing innovative products and services they will have a strong competitive position on the global market.

Innovations are deeply connected with the strategical management of the enterprises. Effective strategic management is based on knowledge and correct business predictions. Therefore a knowledge management system is needed. It handles with huge volumes of information collected from various sources and extracts the hidden knowledge. Knowledge management system combines the latest achievements in the field of information technologies and has a strategical impact over the business development.

The effective knowledge managemet system needs to have the following functionallyties:

- A tool for extracting and processing the information from various internet sources. It needs to be realized as a multiagent system which unites the activities of big number of intelligent robots. They search the Internet space and extract and structure the available information according to specific rules.
- Data bases and knowledge bases.
- Tools for data analysis and knowledge extraction.
- Forecasting tools.

- Quering capabilities, including adhoc queries.

Conclusion

The small and medium enterprises can be competitible with big corporations by using an effective knowledge management system. Such a system helps them to overcome the missing financial funds needed for their adaptation in the contantly changing environment. Becoming a knowledge and innovation centers small and medium enterprises can dramatically increase their competitive power and their impact on the global market.

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BIVIRTUAL ORGANIZATION AS A QUEUING SYSTEM

Tetiana Palonna, Iurii Palonnyi

Abstract: The main features of virtual organizations are outlined. The mathematical models of functioning of virtual organization are offered on the basis of theory of queuing systems. Characteristics of efficiency are examined.

Keywords: virtual enterprise, virtual laboratory, queuing system.

ACM Classification Keywords: I.6.4 Model Validation and Analysis; K.6.1 Project and People Management - Systems analysis and design.

Introduction

Saturation of goods markets and development of information technologies made possible such kind of organization of productive activity as virtual organization.

In the present work we shall consider such subspecies of virtual organization as a virtual laboratory.

There have been suggested mathematical models of virtual organization functioning on the basis of the queuing theory. The efficiency characteristics are considered.

Problem Statement

Let us consider virtual organization as the combination of three interconnected components: local agents (LA), upper agents (UA) and service [Dawidow, 1992]. For virtual laboratory these components could be interpreted in the following way: local agents – students, upper agents – the educational institution and a server.

In case of a server work we assume, that the assembly of agents represents the source of queries of unlimited capacity, and a server is a queuing system (QS), assigning time for the queries processing [Minzberg, 2001].

The average time for one request handling t_{serv} is composed of the average time of the start of connection t_{start}, time of connection $\bar{t}_{connect}$ and the time of the end of connection $\bar{t}_{end}$: $\bar{t}_{serv} = \bar{t}_{start} + \bar{t}_{connect} + \bar{t}_{end}$, at that the meanings of $\bar{t}_{start}$ and $\bar{t}_{end}$ are small comparing with the value of $\bar{t}_{connect}$. The intensity of handling is a value, inverse to the average time of handling, so we receive:

$$\mu = \frac{1}{\bar{t}_{serv}} = \frac{1}{\bar{t}_{start} + \bar{t}_{connect} + \bar{t}_{end}}.$$

The intensity of arrival of queries from agents we shall indicate as λ.

For the sake of simplification we assume, that the server is the one-channel QS with the refusals. Let's assume that there exist two standard situations in the server operation: 1) the "hot season", when the server can not handle with the flow of requests (such faults could, for example, arise before the session, when the large quantity of lower agents apply with the queries); 2) the "dead season" or the vacations, when the intensity of arrival of service requests sharply drops.

The state of the QS being considered is determined after the number of queries in it:

1) for the virtual organization:
   S_0 - in the system there is no queries;
   S_1 - in the system there is one query and the UA is handling it.
2) for the virtual laboratory:
   S_0 – in the QS there is no queries (the server stands idle);
   S_1 – in the QS there is one query (the server is busy with the handling of the given query).

The transition from S_0 to S_1 takes place depending of the intensity of requests and the probability of the connection confirmation $p_{connect}$.

From the given description of the QS functioning we receive, that the density $d_{01}(t)$ of the system transition from the state S_0 into the state S_1 is equal to the product of $p_{connect}$ by the intensity λ of the incoming flow of queries, and the density $d_{10}(t)$ of the transition from the state S_1 into the state S_0 – to the intensity μ of the flow of queries handling. That is why the transition graph will be of the form, represented at Fig. 1

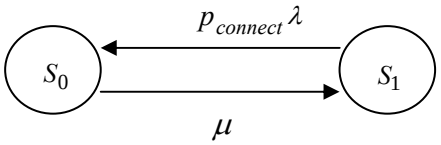

Fig. 1. Transition graph of the interaction model of agents and the server (for virtual laboratory)

Let us assume that all the flows of events in the QS are the simplest. Than in the QS the Markovian process takes place. After the transition graph we receive, that the functioning of the QS is depicted by the Chapman-Kolmogorov differential equation system [Kremer, 2001]:

$$\frac{dp_0(t)}{dt} = -p_{connect}\lambda p_0(t) + \mu p_1(t),$$

$$\frac{dp_1(t)}{dt} = -\mu p_1(t) + p_{connect}\lambda p_0(t),$$

together with the normalization requirement

$$p_0(t) + p_1(t) = 1.$$

We consider, that at the initial moment of time in the system there were no queries, i.e. the system was in the state S_0:

$$p_0(0) = 1,\ p_1(0) = 0.$$

Excluding the second equation of the system and using the normalization requirement we receive the ordinary differential equation:

$$\frac{dp_0(t)}{dt} = -(p_{connect}\lambda + \mu)p_0(t) + \mu.$$

Analytical solution of the mentioned equation taking into account the initial conditions has the looks in the following way:

$$p_0(t) = \frac{\mu}{p_{connect}\lambda + \mu} + \frac{p_{connect}\lambda}{p_{connect}\lambda + \mu} e^{-(p_{connect}\lambda + \mu)t},\ p_1(t) = 1 - p_0(t).$$

Similarly after the transition graph we can obtain the balance equation (for the sake of establishing the working regime of the system):

$$p_{connect}\lambda p_0 = \mu p_1,\ \mu p_1 = p_{connect}\lambda p_0,\ p_0 + p_1 = 1,$$

from where the values of probabilities of the system states are calculated:

$$p_0(t) = \frac{\mu}{p_{connect}\,\lambda + \mu},\ p_1(t) = \frac{\mu}{p_{connect}\,\lambda + \mu}.$$

Let us consider the simplest model of interaction of the LA and the service. If ν is the intensity of offers from service to the LA, and η is the intensity of theirs accepting by the LA, then there are two stable states of the system: S_0^1 - the proposal is accepted, S_1^1 - the proposal is not accepted.

Model of interaction of the agent and the server is considered similarly. Let ν be the billing intensity by the server to the agent; and η – the intensity of theirs payment by the agent. As earlier, let us assume, that all the flows of the events are the simplest flows and consequently in the system the Markovian process takes place. Two stable states if the system considered could be distinguished: S_0^1 – the bill is paid, S_1^1 – the bill is unpaid.

Then the transition graph will be of the form, represented at Fig. 2.

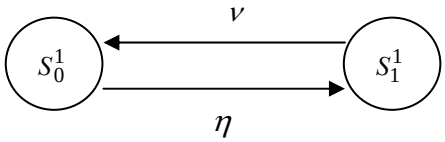

Fig. 2. Transition graph of the interaction model of the local agents and the service

Solving the given problem similarly to the previous one, we shall receive the probability values of the QS state for the steady-state working regime

$$P_0 = \frac{\eta}{\nu}, P_1 = \frac{\eta}{\nu + \eta}.$$

Integrating the received simplest modes we shall obtain the QS with four states:

1) for virtual organization:
   - S_{00} - the UA is free, the proposal has been accepted;
   - S_{01} – the UA is free, the proposal has not been accepted;
   - S_{10} - the UA is occupied, the proposal has been accepted;
   - S_{11} – the UA is occupied, the proposal has not been accepted.
2) for virtual laboratory:
   - S_{00} - the server is free, the bill is paid;
   - S_{01} - the server is free, the bill is unpaid;
   - S_{10} - the server is occupied, the bill is paid;
   - S_{11} - the server is occupied, the bill is unpaid.

Describing functioning of the QS as changes of its states we can obtain the transition graph, represented at Fig. 3.

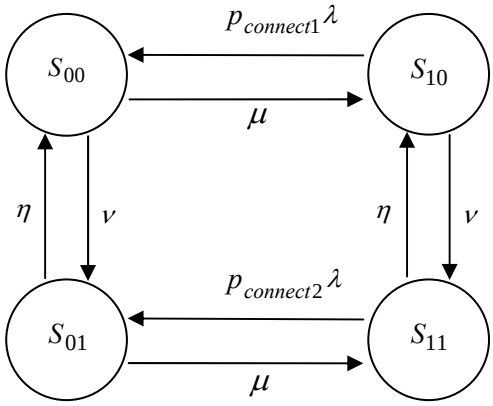

Fig. 3. Transition graph of the integrated model (of the fragment of virtual organization)

Balance equation

After the transition graph we obtain the mathematical model of the system functioning - the balance equation:

$$(p_{connect1}\lambda + \nu)p_{00} = \mu p_{10} + \eta p_{01},$$
$$(\mu + \nu)p_{10} = p_{connect1}\lambda p_{00} + \eta p_{11},$$
$$(\eta + p_{connect1}\lambda)p_{01} = \nu p_{00} + \mu p_{11},$$
$$(\mu + \eta)p_{11} = p_{connect2}\lambda p_{01} + \nu p_{10},$$
$$p_{00} + p_{10} + p_{01} + p_{11} = 1.$$

Solution of the given system of linear algebraic equations looks in the following way:

$$p_{00} = \frac{1 - \alpha_2 p_{11}}{\alpha_1},$$

$$p_{01} = \frac{1-\beta_2 p_{11}}{\beta_1},$$

$$p_{10} = \frac{1-\gamma_2 p_{11}}{\gamma_1},$$

$$p_{11} = \frac{2}{(\frac{\alpha_2}{\alpha_1} + \frac{\beta_2}{\beta_1} + \frac{\gamma_2}{\gamma_1})},$$

where

$$\alpha_1 = 1 + \frac{\nu}{\eta + p_{connect2}\lambda} + \frac{p_{connect1}\lambda}{\mu + \nu},$$

$$\alpha_2 = 1 + \frac{\mu}{\eta + p_{connect2}\lambda} + \frac{\eta}{\mu + \nu},$$

$$\beta_1 = 1 + \frac{\eta + p_{connect2}\lambda}{\nu} + \frac{p_{connect2}\lambda}{\nu},$$

$$\beta_2 = 1 - \frac{\mu}{\nu} + \frac{\mu + \eta}{\nu} = 1 + \frac{\eta}{\nu},$$

$$\gamma_1 = 1 + \frac{\mu + \nu}{p_{connect1}\lambda} - \frac{\nu}{p_{connect1}\lambda} = 1 + \frac{\mu}{P_{connect1}\lambda},$$

$$\gamma_2 = 1 - \frac{\eta}{p_{connect1}\lambda} - \frac{\mu + \eta}{p_{connect2}\lambda} = 1 - \frac{\mu}{P_{connect2}\lambda}.$$

Characteristics of functioning of virtual laboratory (virtual organization)

After the proposed model the following system characteristics are calculated:

- probability of the refusal because of the bill, unpaid by the agent $P_{ref,unb} = p_{00}(1 - p_{connect1}) + p_{01}(1 - p_{connect2})$
- probability of the refusal because of the occupancy of the server (consequently, the UA) $P_{ref,s} = p_{10} + p_{11}$
- probability of the refusal of the servicing $P_{ref} = P_{ref,unb} + P_{ref,s}$
- relative throughput $q = 1 - P_{ref} = p_{00}p_{connect1} + p_{01}p_{connect2}$
- absolute throughput $A = \lambda q$
- average time of staying of the query in the system $\overline{Z} = \frac{A}{\mu} = \frac{\lambda}{\mu} q = \rho(1 - P_{ref}) = \rho p_{00} p_{connect1} + \rho p_{01} p_{connect2}$

Conclusion

The mathematical models of functioning of virtual organizations, namely of virtual laboratories in the capacity of one-channel queuing system with the refusals were considered. The characteristics of functioning of the considered objects were analysed.

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EXPERT SYSTEM FOR DECISION-MAKING PROBLEM IN ECONOMICS

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Abstract: An expert system (ES) is a class of computer programs developed by researchers in artificial intelligence. In essence, they are programs made up of a set of rules that analyze information about a specific class of problems, as well as provide analysis of the problems, and, depending upon their design, recommend a course of user action in order to implement corrections. ES are computerized tools designed to enhance the quality and availability of knowledge required by decision makers in a wide range of industries. Decision-making is important for the financial institutions involved due to the high level of risk associated with wrong decisions. The process of making decision is complex and unstructured. The existing models for decision-making do not capture the learned knowledge well enough. In this study, we analyze the beneficial aspects of using ES for decision-making process.

Keywords: expert system, decision-making processing

1. Introduction

The purpose of this paper is to develop an expert system as an interactive computer program that helps a user solve a problem and make a right decision. Decision making process is inherently complex due to the various forms of risks involved. The existing models for decision-making do not capture the learned knowledge well enough [1-3,5]. In this paper, we analyze the beneficial aspects of using ES for decision-making process and organized as follows: Section 2 provides types of problems in economics solved by ES. Section 3 includes the comparison analysis. Inference rule and confidence are given in Section 4. Section 5 concludes the paper.

2. Types of Problems in economics Solved by ES

Typically, the problems to be solved are of the sort that would normally be tackled by a human “expert” – an economical or other professional, in most cases. Real experts in the problem domain are asked to provide "rules of thumb" on how they evaluate the problems, either explicitly with the aid of experienced system developers, or sometimes implicitly, by getting such experts to evaluate test cases and using computer programs to examine the test data and derive rules from that. Generally expert systems are used for problems for which there is no single "correct" solution which can be encoded in a conventional algorithm — one would not write an expert system to find shortest paths through graphs, or sort data, as there are simply easier ways to do these tasks. Simple systems use simple true/false logic to evaluate data, but more sophisticated systems are capable of performing at least some evaluation taking into account real-world uncertainties, using such methods as fuzzy logic. Such sophistication is difficult to develop and still highly imperfect.

3. ES in Comparison with traditional Problem-solving Systems

The principal distinction between expert systems and traditional problem solving programs is the way in which the problem related expertise is coded. In traditional applications, problem expertise is encoded in both program and data structures. In the expert system approach all of the problem related expertise is encoded in data structures only; none is in programs. Several benefits immediately follow from this organization. An example may help contrast the traditional problem solving program with the expert system approach. The example is the problem of tax advice. In the traditional approach data structures describe the taxpayer and tax tables, and a program in which there are statements representing an expert tax consultant's knowledge, such as statements, which relate information about the taxpayer to tax table choices. It is this representation of the tax expert's knowledge that is difficult for the tax expert to understand or modify. In the expert system approach, the information about taxpayers and tax computations is again found in data structures, but now the knowledge describing the relationships between them is encoded in data structures as well. The programs of an expert system are independent of the problem domain and serve to process the data structures without regard to the nature of the problem area they describe.

An expert system has four main architectural components that are the knowledge base, the inference engine, the knowledge acquisition module, and the user interface for input/output (Figure 1). The knowledge base contains the domain specific knowledge that is used for problem solving in the domain. Knowledge can be represented and stored in the knowledge base with a format suitable for computer manipulation. One of the most commonly used ways to represent knowledge is as rules (in the form of If-then) [2].

The inference engine is based on an inference rule and a search strategy and contains algorithms. Algorithms are used to manipulate the knowledge stored in the knowledge base in order to solve problems. An inference rule is a way to deduce new knowledge from the existing knowledge base of rules and facts. The knowledge acquisition module enables experts to store their knowledge in the knowledge base or expert system to deduce new knowledge from existing knowledge through a machine learning process. The interface for input/output is used for the expert system to interact with the user, the environment and other systems such as databases, and spreadsheets.

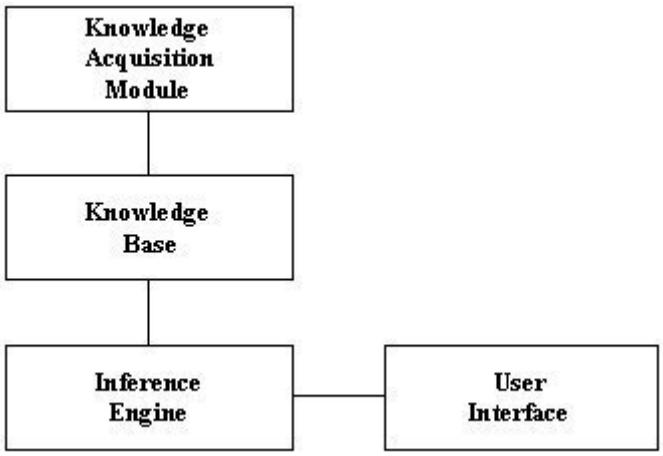

Figure 1. The Architecture of an Expert System

There are generally three individuals having an interaction with expert systems in organization. Primary among these is the end-user; the individual who uses the system for its problem solving assistance. In the building and maintenance of the system there are two other roles: the problem domain expert who builds the knowledge base, and a knowledge engineer who assists the experts in determining the representation of their knowledge and who defines the inference technique required to obtain useful problem solving activity. The end-user usually sees an expert system through an interactive dialog. Knowledge engineers are concerned with the representation chosen for the expert's knowledge declarations and with the inference engine used to process that knowledge.

4. The Inference rule and Confidence

An understanding of the "inference rule" concept is important to understand expert systems. An inference rule is a statement that has two parts, an if-clause and a then-clause.

An expert system's rulebase is made up of many such inference rules. They are entered as separate rules and it is the inference engine that uses them together to draw conclusions. Because each rule is a unit, rules may be deleted or added without affecting other rules (though it should affect which conclusions are reached). One advantage of inference rules over traditional programming is that inference rules use reasoning which more closely resemble human reasoning. Thus, when a conclusion is drawn, it is possible to understand how this conclusion was reached. Furthermore, because the expert system uses knowledge in a form similar to the expert, it may be easier to retrieve this information from the expert.

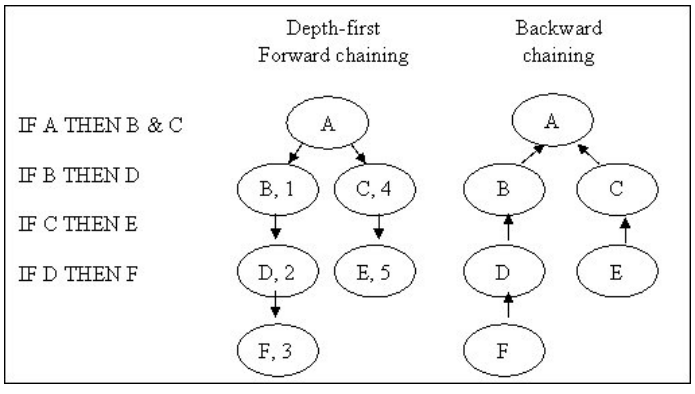

Figure 2. Complex rules

Actually there are two methods of reasoning when using inference rules: Forward chaining and backward chaining. Forward chaining starts with the available data and uses inference rules to extract more data until

an optimal goal is reached. An inference engine using forward chaining searches the inference rules until it finds one where the If clause is known to be true. When found it can conclude, or infer, the Then clause, resulting in the addition of new information to its dataset. Backward chaining starts with a list of goals (or a hypothesis) and works backwards to see if there are data available that will support any of these goals. An inference engine using backward chaining would search the inference rules until it finds one, which has a Then clause that matches a desired goal. If the If clause of that inference rule is not known to be true, then it is added to the list of goals (in order for your goal to be confirmed you must also provide data that confirms this new rule). The complex rules are demonstrated bellow in the Figure 2 [6]:

Another advantage of expert systems over traditional methods of programming is that they allow the use of confidences. When a human reasons he does not always conclude things with 100% confidence. The user might say, "If the rate is blue, then it is probably increasing". This type of reasoning can be imitated by using numeric values called Confidences. For example, if it is known that rate is blue, it might be concluded with 0.85 Confidence that it is increasing. These numbers are similar in nature to probabilities, but they are not the same. They are meant to imitate the Confidences humans use in reasoning rather than to follow the mathematical definitions used in calculating probabilities [4].

5. Conclusion

The following general points about ES:

A. The sequence of steps taken to reach a conclusion is dynamically synthesized with each new case. It is not explicitly programmed when the system is built.

B. ES can process multiple values for any problem parameter. This permits more than one line of reasoning to be pursued and the results of incomplete (not fully determined) reasoning to be presented.

C. Problem solving is accomplished by applying specific knowledge rather than specific technique. This is a key idea in expert systems technology. It reflects the belief that human experts do not process their knowledge differently from others, but they do possess different knowledge. With this philosophy, when one finds that their expert system does not produce the desired results, work begins to expand the knowledge base, not to re-program the procedures.

So, the ES, including knowledge base, production rule and inference engine, provide a rich and meaningful addition to the traditional methods. This approach is also most likely to be used in a real-world implementation of a decision support system. In this paper we have analyzed the beneficial aspects of using expert system for decision-making process. The kernel of the discussed system is Access DBMS and programming language Visual Basic.

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